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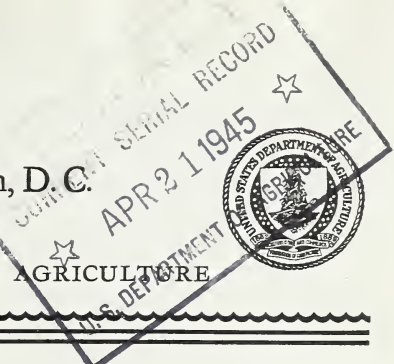


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A Commercial Cabbage Culture

By VICTOR R. BOSWELL, *principal horticulturist and assistant head of division, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

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INTRODUCTION

Cabbage has been used as human food for probably 4,000 years. It was used by the ancient Greeks and Egyptians and has been grown by Europeans for about 1,000 years. The early forms were doubtless quite different from present varieties, which, together with cauliflower, kale, and other related forms, have been developed from wild types presumably similar to the wild cabbage that is found growing at present on the chalk cliffs of England, on the sea-coasts of Denmark, in northwestern France, and in other similar regions of Europe.

Cabbage is a member of the mustard family and a botanical variety of the species *Brassica oleracea*. It is closely related botanically to other members of the species, such as kale, collards, cauliflower, brussels sprouts, broccoli, and kohlrabi, and will cross readily with them.

### COMPOSITION AND FOOD VALUE

According to Chatfield and Adams (8),<sup>1</sup> the average composition of cabbage is as follows: Water, 92.4 percent; protein, 1.4 percent; fat, 0.2 percent; ash, 0.75 percent; fiber, 1 percent; and sugars, 3.5 percent. The fuel value per pound of the edible portion is 130 calories, but on account of the parts discarded as waste in preparing cabbage for the table, the fuel value per pound as it is purchased or prepared for market is about 90 calories. This fuel value compares favorably with that of asparagus, broccoli, beet greens, chard, mustard, cauliflower, spinach, tomatoes, and eggplant, but it is somewhat lower than the value of beets, carrots, and onions. Such vegetables as beans, peas, sweet corn, and potatoes are much higher in fuel value than cabbage.

Although relatively low in fuel value, cabbage when raw is particularly rich as a source of vitamins B and C. The green leaves are also rich in vitamin A, but the blanched or white leaves contain only a small amount. Results of studies by Smith (21) show that green raw cabbage compares favorably with lettuce and tomatoes as a source of all three vitamins; it is superior in content of B and C to asparagus, beets, eggplant, and onions and contains more A and C than snap beans, beets, carrots, cauliflower, eggplant, and onions.

### RANGE OF CULTURE AND COMMERCIAL IMPORTANCE

Cabbage is grown throughout the United States except in regions in which no vegetables can be grown. The large commercial plantings are found in locations especially favorable because of fertile soil or suitable climate. It is grown as a winter and early-spring crop in the South and as a summer or fall crop in the Northern States and at high altitudes.

The influence of temperature and rainfall upon the growth of cabbage is very pronounced and determines to a large extent the principal regions for growing. Although the crop is grown to a fair extent on nonirrigated lands of the Middle West, the most extensive nonirrigated areas are not far from the Great Lakes or in the Atlantic States where the rainfall averages 35 to 40 inches or more per year and is well distributed throughout the growing season. Light soils and soils deficient in organic matter are not suitable for cabbage culture in regions of low water supply because they have such low water-holding capacity that the crop suffers severely from a deficiency of water. Cabbage requires an abundant and reasonably uniform supply of moisture.

In commercial acreage cabbage ranks seventh to ninth among vegetables grown for market or canning and manufacture, being surpassed by tomatoes, sweetpotatoes, sweet corn, early potatoes, peas, and watermelons and in some years by snap beans and cucumbers.

<sup>1</sup> Italic numbers in parentheses refer to Literature Cited, p. 59.

In value the cabbage crop ranks sixth or seventh, generally being exceeded by sweetpotatoes, tomatoes, early potatoes, lettuce, and peas and sometimes by muskmelons. The commercial acreage varies from about 160,000 to 180,000 acres in different years; annual production is in the neighborhood of a million tons, and the value of the crop varies from about \$15,000,000 to \$20,000,000 annually.<sup>2</sup>

### PURPOSES FOR WHICH CABBAGE IS GROWN

In separate regions the crop is produced to be used for specific purposes and to be handled and marketed by different means. These various types of commercial culture of cabbage for different objects or purposes may be listed as follows:

In the vicinity of towns or cities the crop is grown in small market-garden or truck districts and is intended for immediate local consumption. Such developments are not confined to one region in the country but are well distributed over it.

In extensive truck-crop sections, roughly in the southern third of the country, cabbage is grown so as to reach the harvest stage in the winter or early spring, the crop being intended for shipping considerable distances northward in the fresh green state. The more important of these sections are in the central and southern parts of Florida and Texas and in California, Louisiana, Mississippi, Alabama, South Carolina, Virginia, and Maryland.

Cabbage is grown on a large scale as a summer or fall crop in central and western New York, Wisconsin, Ohio, Michigan, and north-central Colorado. Part of this crop is marketed for use immediately after being harvested, but most of it either is stored for distribution through the fall and winter or is manufactured into sauerkraut.

More detailed information on the locations of the important cabbage-growing sections will be found in United States Department of Agriculture Technical Bulletin 646, Marketing Commercial Cabbage (22).

### PURPOSE AND SCOPE OF THIS CIRCULAR

In this circular no attempt is made to present a comprehensive description and review of the details of cultural methods and field practices that prevail in different regions. Anyone contemplating the culture of cabbage in any part of the country where the crop is commonly grown can easily observe the details of culture that experience has shown to be fairly satisfactory in that particular locality, and some such actual contact with growing operations is essential to a working knowledge of the crop in each general region where it is grown. The purpose here is to present a few typical practices together with some less commonly known information and principles which will afford a sound basis for successful production. This information has been drawn from practice and scientific investigations in many States. The individual grower must adapt these principles and facts to his own local conditions, guided by his own experience and that of others in the locality.

The more elementary points in the culture of cabbage are covered in Farmers' Bulletin No. 1673, The Farm Garden (4).

<sup>2</sup> Detailed data on acreage, production, and values can be obtained by writing to the Bureau of Agricultural Economics, U. S. Department of Agriculture, Washington 25, D. C.

## EFFECTS OF TEMPERATURE

### GENERAL EFFECTS

Cabbage is a cool-season plant that makes its best development in the spring or fall in most parts of this country. Only in the Northern States or at high altitudes does it succeed when planted so that most of its growth occurs during the summer. Even though an abundance of plant food and water is available, normal growth and head formation will not result if the temperatures are high for a period of weeks, especially during the latter half of the time usually required for a variety to reach the market stage. Temperatures between 95° and 100° F., which commonly occur through the southern two-thirds of the country in midsummer, are distinctly harmful, especially if the nights also are warm. If the nights are usually rather cool, as in regions of high altitude, high temperatures for a few hours during the day are not particularly harmful.

The dates for sowing and transplanting which prevail in each region where the crop is grown commercially have been adopted through trial and error, and are carefully adapted so that excessive temperatures generally will be avoided during the later part of the plant's growth. Long-season or late varieties such as Danish Ballhead, Late Flat Dutch, and Wisconsin Hollander are apparently unsuited to those parts of the country in which the mild growing weather of spring quickly gives way to the intense heat of summer and in which the winter is too cold for growth. Only rapidly developing sorts like Early Jersey Wakefield, Golden Acre, Copenhagen Market, and Glory of Enkhuizen are suited to such regions.

Cabbage is hardy to cold if grown under a gradually lowering temperature such as normally occurs in the fall. Under these conditions it will endure light freezes without injury, but unseasonable frosts that sometimes occur during a period of otherwise warm weather and during the fairly rapid growth of the plants usually cause severe injury or death. Small plants grown in the fall and subjected to a gradual lowering of temperature become exceedingly resistant to cold, being able to withstand a temperature of 10° F., and for short periods under conditions not too unfavorable even temperatures as low as 0°.

### EFFECTS ON PREMATURE SHOOTING TO SEED

In those Middle Atlantic and Southern States where cabbage is planted in the fall and carried over winter in the open field, an appreciable percentage of the plants may "shoot to seed" in the spring instead of forming heads, largely as a result of temperature conditions. This premature formation of flower stalks is a more common trouble in Maryland, Virginia, and the Carolinas than in the cabbage sections of the Gulf States. In Maryland, Virginia, and the Carolinas a small percentage of "seeders" usually is expected, but in some seasons it may be as high as 60 to 70 percent of the plants in the field, or even more. Premature seedstalk formation sometimes occurs in fields of cabbage that are transplanted in the spring, but serious losses are not common. It must be emphasized that when seeders become evident



in a field of cabbage it is too late to correct the trouble. When the plant has developed into a seeder to the extent that seedstalks are visible, there is no practical way of changing it into a type of plant that will form a good marketable head. Therefore it is important that the grower understand the conditions which cause premature seed-stalk formation, or bolting, as it is often called, so that the trouble can be prevented so far as possible. Unfortunately, it cannot always be prevented.

Cabbage is a biennial plant; that is, it normally requires two seasons, or parts of two seasons, in which to complete its development from the seedling stage to the formation of flowers and maturing of seeds. Under favorable conditions in the first season of growth the plant forms a rosette of leaves and a head; that is, a compact arrangement of leaves about the upper part of the stem of the plant. Miller (19), working at the Agricultural Experiment Station of Cornell University, has shown that if it is desired to obtain seed from plants that have formed heads, these plants must have a period of rest of about 2 months under conditions of temperature low enough to stop temporarily outward evidences of growth, but not necessarily cold enough to freeze the plant. When the temperature is raised to that similar to good growing weather in the spring, flower stalks, flowers, and finally seed will be produced. Merely checking the development of the plants by withholding water, or by other means, at a warm temperature (60° to 70° F. or higher) will not result in flower and seed development. A cool temperature, as low as 40° to 50°, is absolutely necessary, and even lower temperatures may be effective. Later, unpublished observations of workers of this Department and of the Texas and Wisconsin Agricultural Experiment Stations indicate that these temperatures are effective in making headed cabbage produce flowers only when they follow a gradually descending temperature, such as normally occurs in autumn.

Small cabbage plants also behave in a similar fashion. It is not necessary for a plant to develop to the heading stage before flower-stalk formation can be induced by a period of low temperature which is followed by good growing conditions. This is well known because of the occurrence of premature seeders, or bolters, in the field. The question arises, then, Why do only 10, 20, or perhaps 50 percent of the plants in a field produce seedstalks in certain seasons? If cold weather causes bolting, as well as being necessary for seed formation in headed plants, why do only part of the plants in the field go to seed prematurely?

#### OVERWINTERED CABBAGE

Studies of overwintering of Early Jersey Wakefield and Charleston Wakefield varieties by Boswell (6) in Maryland have shown that the size of the plant at the time it is exposed to cold is of very great importance in determining whether or not a seeder will result in the spring. Plants with stems larger than one-fourth inch bolted very badly; the larger the plants, the more of them bolted. For example, of plants with stems three-eighths of an inch maximum diameter,

roughly one-half bolted, and in some instances as many as three-fourths of them produced seeders instead of heads. Plants with maximum stem diameters of about three-sixteenths to one-fourth inch rarely produced over 10 percent of seeders and usually 4 to 7 percent. Plants with stems smaller than three-sixteenths inch produced practically no seeders, but if noticeably smaller than three-sixteenths inch, they were very susceptible to winter-killing. Thus, in regions where cabbage is overwintered under low temperatures and there are protracted periods with the temperature around 40° F. or down to freezing or lower, a higher percentage of bolters may be expected among plants that have stems larger than a lead pencil (approximately three-sixteenths to one-fourth inch).

Sometimes plants of fairly large size (one-fourth to five-sixteenths inch stem diameter) do not produce seedstalks as much as stated in the preceding paragraph, even though the temperature has been low for many weeks during the winter, but in general the hazards are great. It is considered good insurance to use plants no larger than three-sixteenths to one-fourth inch if there is any probability of their being exposed to low temperature for more than 2 weeks, either before or after transplanting.

Fertilizer treatment in the plant bed is without effect on bolting except as it affects the size of the plant, but heavy fertilizing in the plant bed does produce many plants that are too large; a high percentage of such plants become seeders if the weather conditions are such as to induce bolting. Fertilizer treatment in the field is apparently without any effect whatever because it does not influence growth appreciably until after the periods of low temperatures are past.

Even though it is known that bolting of overwintered cabbage is closely associated with the size of the plants at the time cold weather arrives, it is not always possible to control the size of the plants in the plant bed as desired. Sowing the seed as late as it is possible to sow it and still obtain strong, vigorous, winter-hardy plants and using fertilizers judiciously so as to avoid having the plants attain excessive size are the best means of control that are at the grower's disposal. However, if the fall season happens to be unusually warm or growing weather continues unusually late, as it sometimes does, the plants may grow too large in spite of careful planning and management. At present no practicable treatment that will reduce the tendency of such plants to shoot to seed is known. On the other hand, cold weather may arrive unusually early, stopping the growth of plants in the bed while they are so small that they will be severely injured by the colder weather that follows.

The only practicable means of assuring a supply of plants of proper size through avoiding the undesirable results of either unusually early or unusually late cold weather is to make two sowings of seed a week or two apart. The dates of sowing depend upon the normal weather conditions in the sections in question. The sowings should be closer together in the Maryland and Virginia sections than in South Carolina, where the progress of winter weather is slower and where there is more latitude in suitable sowing dates. For example, the usual date of sowing in the vicinity of Baltimore, Md., is approximately September 10. In some seasons this proves to be a little too early,

for the plants become too large before time for transplanting. In other seasons the opposite is true. Sowings made on September 6 and on September 14 would accomplish much to insure a supply of suitable plants. The early sowing may prove too early, and most of the plants may be so large that they will have to be discarded, but in such an event most of the plants from the sowings of September 14 should be of suitable size. If cold weather comes earlier than usual, the September 14 plants may be so small that most of them would be winter-killed and so must be discarded. Even so, a good supply of plants should be available from the September 6 sowing. It is truly remarkable how much difference in plants is obtained by only a week's difference in sowing in the Baltimore district. Farther south, the difference in planting dates needs to be greater in order to produce appreciable differences in the character of the plants grown for transplanting.

This method of avoiding premature seedstalk formation involves the planting of approximately twice the amount of seed that would be sown for a single planting. Good cabbage seed and the growing of plants are fairly costly, but if the percentage of seeders can be held down to 5 or 10 percent or lower, instead of perhaps 25 or 30 percent, the additional cost of extra seed and plant growing is usually justified. Some of the best growers follow the practice just described.

Another method that often can be used successfully to prevent the plants from becoming too large before cold weather arrives is to remove them from the plant bed and transplant them to the field just as soon as they attain the proper size, regardless of the time. This checks the development of the plants considerably, and they will grow but little, if any more, after transplanting and before winter. If this method of controlling plant size is to be used, it is obviously necessary to make plans far enough in advance to have the field available for transplanting considerably earlier than the usual transplanting date.

The Louisiana Agricultural Experiment Station recommends<sup>3</sup> that plants for the spring crop be started at such a time as to reach the required size for setting in the field early in January. Transplantings made before December 10 to 15 are very likely to shoot to seed severely.

#### SPRING-PLANTED CABBAGE

Occasionally there are severe losses in spring-sown, spring planted cabbage, on account of bolting. This is much less common than bolting in the overwintered crop, but losses may be 50 percent or more in certain years. It is caused by essentially the same factors that cause bolting in the overwintered crop, but it is less common because the temperature in the spring after the plants are set rarely remains low long enough to cause bolting. Furthermore, even if the weather is conducive to bolting, plants from late-winter or early-spring sowing rarely are large enough to bolt until after the period of cool weather which could induce bolting has passed. At the same

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<sup>3</sup> Unpublished correspondence.

time it should be remembered that some varieties bolt more easily than others. Golden Acre and Copenhagen Market will bolt severely under conditions which disturb Early Jersey Wakefield very little. There are also pronounced differences between strains in this respect. At this time there is little, if any, possibility of combating bolting in spring-sown cabbage except through the development of strains which do not bolt readily. Strains of Early Jersey Wakefield and Charleston Wakefield which show small tendency to bolt have been observed by Zimmerley (30). Unfortunately, it is not possible to refer growers to sources of such stocks, but they doubtless exist and might be located by growers' trials.

In the competition among growers to obtain earliness and high prices, it is essential to use good-sized, vigorous plants and to set them in the field as early as possible. Using smaller plants or transplanting later would doubtless greatly reduce the amount of bolting in those rare seasons when it is serious. In most seasons, however, these measures would probably serve only to delay harvest and reduce yield and profits, because in the spring-sown crop bolting is rarely serious and the effort to reduce it often will have been made for nothing. Over a period of years the chances for profit with a heavy early yield will probably outweigh the danger of loss by bolting.

There is one precaution, however, that can well be taken with the spring-transplanted crop. The source of the plants to be used should be definitely known. Plants that have been in a plant bed all winter or have endured low temperature for a period of weeks after the stems have attained the size of a pencil should be used with caution. The size of plant should be kept down, as recommended.

The effects of temperature upon cabbage have been discussed at length because a thorough knowledge and clear understanding of the available information on this subject are of the greatest practical value. Their importance to the cabbage grower is very strongly emphasized.

## CHARACTERIZATIONS OF THE MORE IMPORTANT VARIETIES

In choosing a variety of cabbage, one should make sure that it is adapted to the section in question and that it meets the market requirements. Pointed varieties can be sold with difficulty, if at all, upon markets that demand round heads, and vice versa. Of the scores of so-called varieties of cabbage only about a dozen are needed to cover practically every commercial demand and to suit all conditions under which the crop is commonly grown. Many of the supposed distinctive characters of certain so-called varieties either do not exist at all or are so slight and so unimportant as to merit no serious consideration.

The following characterizations are intended to aid the grower in his selection of strains especially suited to his section and to the purpose for which he wishes to grow cabbage. By using these descriptions in connection with the data given in table 1, he should be able to select desirable stocks for the climate and conditions of his section.

TABLE 1.—*Outstanding characteristics of the more important varieties of cabbage, arranged in approximate order of earliness<sup>1</sup>*

Variety name	Season	Head shape	Head size	Plant size	Reaction to yellows	Principal use
Early Jersey Wakefield	First early	Very pointed	Very small	Small	Susceptible	Market.
Golden Acre	do	Round	Small	do	do	do.
Resistant Golden Acre	do	do	do	do	Resistant	do.
Jersey Queen	Second early	Pointed	Very small	do	do	do.
Copenhagen Market	do	Round	Medium	Medium	Susceptible	Market; sauerkraut.
Charleston Wakefield	do	Pointed	do	Medium large	do	Market; sauerkraut.
Marrion Market	do	Round	do	Medium	Resistant	Market; sauerkraut.
All-Head Select	Early midseason	Deep, flattened	Medium large	Large	do	Sauerkraut; market.
Globe	do	Round	Medium	Medium large	do	do.
Globe	do	do	do	do	do	do.
Glory of Enkhuzen	do	do	do	do	Susceptible	do.
Am Wunnigstadt	do	Pointed	Medium small	do	do	Market
Am Sais	do	Deep, flattened	Large	do	do	Sauerkraut; market.
Early Flat Dutch	Midseason	Flat	Very large	Medium large	do	do.
Wisconsin All Seasons	do	Deep, flattened	Large	Very large	do	do.
Late Flat Dutch	Medium late	Flat	Very large	do	Resistant	do.
Wisconsin Ballhead	Late	Round	Medium large	Large	Susceptible	do.
Danish Ballhead	do	do	do	do	Resistant	Storage; market.
Wisconsin Hollander	do	do	do	do	Susceptible	do.
Wisconsin Hollander	Very late	do	do	Very large	Medium resistant	do.

<sup>1</sup> These descriptions are adapted in part from data obtained by the U. S. Department of Agriculture in cooperation with the Pennsylvania, Wisconsin, California, Texas, and South Carolina Agricultural Experiment Stations and the Virginia Truck Experiment Station.

## VARIETIES NOT RESISTANT TO YELLOWS

**Early Jersey Wakefield** (fig. 1).—Early Jersey Wakefield is the earliest of the important commercial varieties. It reaches harvest generally 65 to 70 days after being transplanted in the spring.

Plant small, 10 to 12 inches in height, spreading 20 to 22 inches. Outer leaves small and few, typically 11 to 13, smooth and nearly flat near the edges, which are entire (not notched or scalloped), mostly spreading well away from the head; head standing out very prominently; bloom, or grayish waxy covering of the leaf, slight. Head very pointed, very small, typically  $1\frac{3}{4}$  to  $2\frac{1}{4}$  pounds; about  $6\frac{1}{2}$  to  $7\frac{1}{4}$  inches long and  $4\frac{1}{2}$  to 5 inches in diameter; top bluntly pointed, not hard; base hemispherical and hard; outermost leaves held tightly well around the head; interior rather loosely formed, with spaces between the leaves; mid-ribs arising from the stem or core at an angle of about  $45^\circ$ ; core small, 1 to  $1\frac{1}{2}$  inches in diameter and 3 to  $3\frac{1}{2}$  inches long, slightly less than half the length of the head.

Some strains sold under the name Early Jersey Wakefield are more like the Charleston Wakefield. These large, coarse types are not true to the variety.

**Golden Acre**.—Golden Acre is early, round-headed, and in general rather similar to Copenhagen Market in appearance. It is about a week earlier than



FIGURE 1.—Early Jersey Wakefield.

Copenhagen Market, the entire plants and the heads are slightly smaller, and the heads appear a little more prominent in the plant because of the proportionately smaller, less numerous outer leaves. Although it is a comparatively new variety, it is one of the most important for spring planting for market. Golden Acre is less hardy to cold and bolts much more readily than Early Jersey Wakefield and Charleston Wakefield, making it unsuited to overwintering in areas that have much freezing weather.

**Copenhagen Market** (fig. 2).—Copenhagen Market is a second-early variety; it reaches harvest 70 to 75 days after being transplanted.

Plant medium-sized, about 9 to 11 inches tall, spreading 22 to 25 inches; outer leaves medium in size and number, typically 14 to 16, curving broadly outward and upward from base of plant, standing well away from head and giving plant as a whole a somewhat cup-shaped appearance; most leaves rather uniformly curved up into the shape of the bowl of a rounded spoon; tips of leaves standing at nearly the same level above the soil and slightly above the head; leaf surfaces slightly undulate (irregularly wavy), edges slightly crenate (faintly scalloped); ribs and veins conspicuous; bloom, or grayish waxy covering, moderate in amount, giving the leaves a medium-green color. Head medium-sized, typically 3 to 4 pounds (much larger heads not suitable for early market), measuring 6 to 7 inches in diameter at its equator and  $5\frac{3}{4}$  to  $6\frac{3}{4}$  inches from top to base; globe-shaped in appearance; compact and hard. Outermost head leaves lying close against those beneath but easily removable; light yellow green in marked contrast to outer leaves of plant; smaller ribs and veins prominent. Interior of head appearing medium compact, with very little space between



FIGURE 2.—Copenhagen Market.

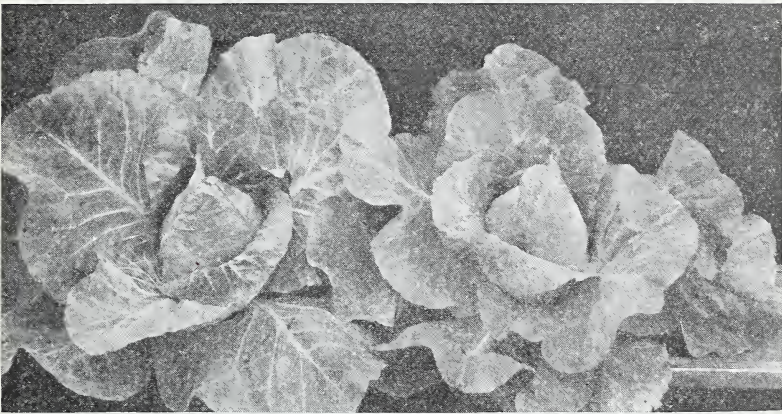


FIGURE 3.—Charleston Wakefield.

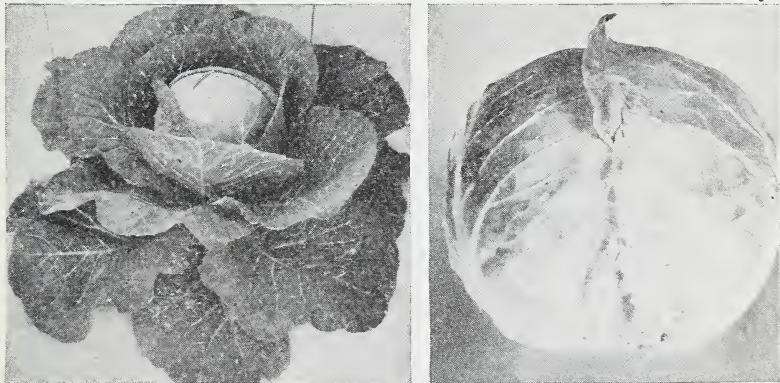


FIGURE 4.—Glory of Enkhuizen.

leaves; midribs arising from the stem or core at an angle of about  $40^\circ$  above horizontal; core medium-sized,  $1\frac{1}{4}$  to  $1\frac{1}{2}$  inches in diameter at the middle and 3 to  $3\frac{1}{2}$  inches long, slightly more than half the length of the head.

This variety is probably the most important of the early sorts.

**Charleston Wakefield** (fig. 3).—Charleston Wakefield is a second-early variety; it is ready for harvesting about 75 days after being transplanted in the spring.

Similar to Early Jersey Wakefield except that plant is distinctly larger; later it has more leaves and is coarser in appearance; the heads are larger and of slightly greater diameter in proportion to their length.

Strains resembling Charleston Wakefield are sometimes sold as Early Jersey Wakefield.

**Glory of Enkhuizen** (fig. 4).—Glory of Enkhuizen is an early-midseason variety; it reaches harvest 85 to 90 days after being transplanted in the spring.

Plant medium large, 11 to 12 inches tall, spreading 24 to 28 inches; leaves many, 17 to 20, and large; very similar to Copenhagen Market in general appear-



FIGURE 5.—All Seasons.



ance, except distinctly larger, and bloom, or grayish waxy covering, of the leaves slightly heavier, giving the leaves a medium grayish-green color. Head almost globular, medium-sized, typically 5 to 6½ pounds, compact and hard, and constituting about 70 percent (an unusually high proportion) of entire plant; measuring 7 to 8 inches in diameter at its equator and about 7 inches from top to base. Outer head leaves reaching slightly past the center of the top and well around the sides, lying tightly against the underlying leaves; ribs and veins prominent. Head color medium yellowish green, in moderate contrast to outer-leaf color; bloom light. Interior of head similar to Copenhagen Market in appearance except that the stem or core is proportionally smaller, measuring 1¼ to 1½ inches in diameter at the middle and 3 to 3½ inches in length, and reaching slightly less than halfway to the top of the head.

It is popular for early-midseason shipping and also as a later crop for sauerkraut manufacture.

**All Seasons** (fig. 5).—All Seasons reaches harvest 90 to 95 days after being transplanted in the spring or early in the summer.

Plant very large, 11 to 13 inches tall, spreading from 30 to 34 inches; outer leaves numerous, usually 18 to 22, forming about 35 percent of the total weight of the plant, very spreading, thus giving the plant an open, spreading appearance, little inward curving of leaves except those close to the head; distinctly gray green



FIGURE 6.—Early Winnigstadt.

in color; leaf surfaces nearly smooth, but slightly undulate except for the borders, which are slightly undulate or wavy; edges slightly scalloped; ribs and veins conspicuous. Head very light green in color, in moderate contrast to leaf color; large, hard, typically 5½ to 7 pounds, measuring 8 to 9½ inches in diameter and 6 to 6½ inches from top to base, being of the flat type, but not so distinctly flattened as the Flat Dutch varieties; top and base broadly rounded; slightly angular in cross section on account of flattening of sides at midribs of head leaves; ribs and veins inconspicuous; bloom light; interior medium compact, with very little space between the leaves; midribs arising from the stem or core usually at right angles to the core or slightly above the horizontal; core above medium size, 1¼ to 1½ inches in diameter at the center, and 3 to 3½ inches long, generally extending nearly two-thirds of the distance from the base to the top of the head.

All Seasons is a midseason variety that is grown for market or sauerkraut.

**Early Winnigstadt** (fig. 6).—The name Early Winnigstadt is misleading, because it is not an early variety, but an early-midseason variety that reaches harvest 85 to 90 days after being transplanted in the spring.

Plant very large, 13 to 15 inches tall, spreading 28 to 34 inches; widely spreading leaves somewhat elongated and having wavy or coarsely frilled margins; outer leaves medium in number, usually 14 to 16, very large; leaves very slightly curved except those clasping the head, outermost having very distinct petioles, or leafstalks; ribs and veins prominent in height and color; bloom, or waxy

covering, very heavy, giving the plants a distinctly grayish color. Stem tall and very large, with numerous large buds or miniature heads where the outer leaves are attached to the stem. Head small to medium in size, typically  $2\frac{1}{2}$  to 3 pounds and constituting only about 35 to 40 percent of the total plant weight (less than in other commercial varieties), measuring 7 to  $7\frac{1}{2}$  inches long and 5 to  $5\frac{3}{4}$  inches in diameter, distinctly pointed; the base sharply rounded, and the



FIGURE 7.—Late Flat Dutch.

cross section slightly elliptical; point well filled and hard, and the other parts very hard; outer head leaves extending about two-thirds around the head, an unusual distance, and held tightly against the leaves beneath; outermost head leaves extending slightly above the point of the head and curving outward, forming a characteristic leafy tuft or tip; interior unusually compact, with practically no spaces between the leaves; midribs arising from the stem or core at an angle of about  $60^\circ$  (more nearly erect than in other varieties); core thick and short, distinctly conic in shape,  $1\frac{1}{2}$  to 2 inches in diameter and  $2\frac{1}{2}$  to 3 inches long.

Early Winnigstadt is grown mainly for late-fall and winter shipping in the mild sections of the Pacific Coast States. After becoming firm, it will stand in the field longer without bursting than other commercial varieties.

**Early Flat Dutch.**—See table 1.

**Late Flat Dutch** (fig. 7).—Late Flat Dutch is a medium-late variety; it reaches harvest in about 100 to 105 days.

Plant very large, 12 to 14 inches tall, spreading 32 to 36 inches, appearing flattened or distinctly spreading; outer leaves broad, nearly flat, numerous, typically 20 to 22, having distinct petioles, or leafstalks, and standing a little above horizontal, curving slightly upward and inward across the blade; inner leaves standing nearly erect and arranged close together, giving an appearance of denseness or leafiness; ribs prominent in height, moderately conspicuous in color; veins not prominent in height and markedly light in color; bloom, or waxy covering, medium heavy, giving a gray-green appearance. Head very large, typically 7 to 8 pounds, measuring  $9\frac{1}{2}$  to 11 inches in diameter and 6 to  $6\frac{1}{2}$  inches from top to base, being distinctly flattened, round in cross section; top and base hard; outer head leaves reaching the center of the head and rather loosely held; head interior medium compact, with inner leaves crumpled; midribs usually sloping downward from the core or stem for a short distance, then curving sharply upward and over; core medium large, about  $1\frac{1}{2}$  inches in diameter and 3 to 4 inches long, extending two-thirds of the length of the head.

It is grown to a limited extent for late local markets, but chiefly for late shipping and sauerkraut.

**Danish Ballhead** (fig. 8).—Danish Ballhead reaches harvest usually in 105 to 115 days, but it may require 125 days in cooler regions.

Plant large, 13 to 15 inches tall, spreading 24 to 28 inches; stem taller than in most varieties; outer leaves many, typically 20 to 22, large and broadly rounded at tips; outermost leaves horizontal or drooping, mostly standing well away from the head, and the next inner leaves curving broadly upward with the tips curving slightly outward, giving the plant an open or loose rosette appearance; outer leaves nearest the head lying close to the head from its base to middle, then bending sharply away; leaves nearly smooth but broadly curved; borders very slightly wavy and edges just perceptibly scalloped; bloom, or waxy covering, heavy, giving a silver-green color. Head medium large, typically 5 to 6 pounds (heavy for its apparent size), measuring 7 to 8 inches in diameter and 6 to 7 inches from top to bottom, diameter being about one to one and one-fourth times the depth; broadly rounded to slightly flattened over top and somewhat elongated toward base; top and base very hard and interior very compact; outer head leaves reaching barely past the center and held tightly; bloom medium; directions of midribs arising from the stem or core are characteristic, those near the base at an angle of about  $30^\circ$ , those in the middle horizontal; core rather large,  $1\frac{1}{2}$  to 2 inches in diameter and  $3\frac{1}{2}$  to 4 inches long, reaching two-thirds of the length of the head.

Danish Ballhead is a late variety grown to a limited extent for late local marketing, but chiefly for late shipping and storage.



FIGURE 8.—Danish Ballhead.

### VARIETIES RESISTANT TO YELLOWS

Over a period of about 20 years the United States Department of Agriculture and the Wisconsin Agricultural Experiment Station developed a large number of varieties that are resistant to the disease known as cabbage yellows, or fusarium wilt. Each resistant variety listed here was developed as a counterpart of an important nonresistant kind and in general can replace that nonresistant variety where yellows causes damage. Instead of describing most of the resistant varieties reference is made to the nonresistant varieties they resemble.

**Jersey Queen.**—Similar to Early Jersey Wakefield, but the heads are less sharply pointed.

**Marion Market.**—Resembles Copenhagen Market, but it is about a week later.

**Resistant Golden Acre.**—Also called Resistant Detroit; a moderately resistant early variety of the Golden Acre type from Denmark.

**Globe.**—In effect, a resistant Glory of Enkhuizen.

**Wisconsin All Seasons.**—A little later than its parent variety, All Seasons, which it otherwise resembles.

**All Head Select.**—A flat variety derived from All Head Early. It is about 10 days earlier than Wisconsin All Seasons.

**Wisconsin Ballhead.**—A new resistant type of Danish Ballhead that resembles that parent variety much more closely than the first resistant type (Wisconsin Hollander) derived from it.

**Wisconsin Hollander.**—Although derived from Danish Ballhead, it is distinctly different. It is late, reaching harvest in 110 to 120 days. Plants very large, coarse, and variable; 14 to 16 inches tall, spreading 28 to 32 inches; stem taller than other varieties, with base of head 6 to 7 inches above the soil; outer leaves numerous, typically 24 to 28; outermost leaves drooping downward from the tall stem, then curving upward slightly toward the ends; leaves very large and coarse, surfaces slightly crumpled, borders somewhat wavy, and the edges distinctly scalloped, lacking the neat appearance of most varieties; bloom, or waxy covering, heavy, giving a silver-green appearance. Heads similar to Danish Ballhead.

### IMPORTANCE OF GOOD SEED

Most cabbage growers have been disappointed at one time or another by the presence of a large proportion of mixtures or offtype plants in their fields. Plants that fail to head, although conditions are proper for good head formation, heads of undesirable shape, or heads that reach harvest stage too early or too late are all serious losses. Probably the seed stocks of no other vegetable crop are more subject to criticism because of lack of uniformity and the presence of undesirable types.

On account of the complexity of the hereditary make-up of the cabbage plant, much careful work and considerable expense are required to obtain a stock that is uniform and of good type. Furthermore, once a good stock or strain is obtained, it may easily become mixed and offtype because cabbage belongs to a species of plants that is commonly cross-fertilized, that is, the flowers of one plant are fertilized by the pollen from other plants of the same species. If different varieties of cabbage are flowering near one another, they will cross and plants grown from the seed of such crosses will be a mixture of types quite lacking in uniformity. As cabbage will also cross readily with cauliflower, broccoli, brussels sprouts, collards, and kale, which belong to the same species, it must be carefully isolated from such plants when grown for seed. Thus, carelessly grown or carelessly handled stock is very liable to be badly mixed and offtype.

In efforts to lower the cost of production, cabbage growers may attempt to save money by purchasing seed at the lowest possible price. In turn, some seedsmen in their attempts to supply the demand for low-

priced seed and to meet the prices of competitors are forced to offer some poor stocks. Seed sold at a high price is not always good, but it should be evident that really good, uniform, true stocks that have been carefully and properly produced cannot be sold profitably at the lowest prices. Growers must realize that the production of good seed is more costly than that of poor seed, that the grower of good seed deserves a fair profit on his product, and that the best seed available is really the cheapest even though the price be twice that of inferior stock.

The surest method of obtaining good seed is to deal with seedsmen with established reputations for handling good stocks who make no extravagant claims concerning their seeds. Other growers may be consulted as to the satisfaction rendered by specific firms. One should adhere to the well-established and well-known varieties for commercial plantings, trying new introductions only on a small experimental scale until their suitability and value are known.

## LIME

Although fertilizer practices vary rather widely in different areas and may even be different for a spring crop and for a late crop in the same area, strikingly similar results have been obtained all over the country with reference to the beneficial effects of lime applied to very acid soils upon which cabbage is grown. Cabbage is not injured by a slight degree of acidity; therefore lime will be of little if any benefit on only slightly acid soils. Furthermore, if a soil is only slightly acid, there may be danger of applying too much lime unless the acidity is definitely known and the application of lime carefully controlled. An excess of lime is often more serious than a deficiency. One must not guess at lime requirements and lime applications. Even if no damage is done to a crop by improper use of lime, it may be a waste of labor and money.

The results obtained in a 5-year rotation experiment<sup>4</sup> on the muck soil of the Kankakee Valley, near South Bend, Ind., furnish striking proof that lime is practically without beneficial effect on organic soils that are only slightly acid. In this experiment the average yield of the unlimed plots was 9.40 tons per acre, and that of the plots receiving 1 ton of ground limestone per acre was 9.64 tons per acre. The very small increase in yield from the limed area did not pay for the lime. The results were not affected by clubroot (p. 51), as this disease was not present.

In experiments in New Jersey, Blair and Prince (5) applied a ton of calcium limestone per acre to a Sassafras loam at 5-year intervals and a 5-year rotation of vegetable crops was grown for 20 years. The unlimed soil in these experiments remained very strongly acid and produced only 9 tons of cabbage per acre, whereas the soil receiving a ton of limestone every 5 years was rated as only moderately acid, and produced 18½ tons of cabbage. Two adjacent areas were given ½ ton and 2 tons of limestone, respectively, instead of 1 ton. The ½-ton treatment partly corrected the acidity, leaving the soil still strongly acid. However, over 15 tons of cabbage was produced. The 2-ton treatment completely corrected the acidity, but the yield was less than on the moderately acid soil. Most crops do better on a soil

<sup>4</sup> Unpublished data of Bureau of Plant Industry, Soils, and Agricultural Engineering.

just slightly acid than on one which is neutral or alkaline, other things being the same.

Many years ago Harter (14), at the Virginia Truck Experiment Station, showed that 1,200 to 2,000 pounds of lime applied to a strongly acid soil during preparation before transplanting gave very substantial increases in yield that same year. Experiments upon early cabbage in Ohio (Comin and Bushnell (9) and Gourley and Magruder (13)) over a period of 12 years showed that 1 ton of limestone gave an average annual increased yield of over 1½ tons, with a net value of about \$75 per acre per year. The soil used in these experiments was a loam to a fine sandy loam. Before the application of lime it was rather strongly acid, the treatment reducing the acidity to a point considered only moderately acid.

These few experiments show the value of moderate amounts of lime when applied to strongly acid or very strongly acid soils. Presumably the benefits here cited are derived from improved growth of the crop entirely aside from the control of clubroot. No reference to its presence was made. If the disease had been present in the strongly acid soils, the benefits from lime would have been still greater. The effect of lime upon clubroot is discussed on page 51.

Growers can obtain determinations of the lime requirement of their soils through their county agricultural agent or through their State experiment station. These agencies will furnish instructions for taking soil samples and for applying the lime. The lime should preferably be applied in the fall or winter preceding the cabbage, but it may be applied in the spring before the cabbage is transplanted.

## ORGANIC MATTER

Although it is generally recognized by vegetable growers that a plentiful supply of organic matter in the soil is essential to the best results, a few examples of what actually has been obtained with cabbage will emphasize the value of organic matter in growing this crop.

At the Virginia Truck Experiment Station, Harter (14) found that plowing under green cowpeas in the fall before frost gave increases in yield of cabbage the following spring of 150 and 200 percent in two different tests. These results were obtained on soil very low in organic matter which produced very low yields of cabbage on the areas without green manure, even though 3,000 pounds of commercial fertilizer had been added. If the cost of fertilizer is estimated at \$40 per ton and the price of cabbage at only 75 cents per barrel, the increased value of the crop due to plowing under organic matter was about \$40 per acre in the first test and \$75 in the second.

On mineral soils the effect of manure as a source of organic matter, as well as of fertilizer elements, is unquestioned. Experimental results and practical experience on these soils the country over have shown that good yields of cabbage can be obtained by applying 20 to 30 tons of manure per acre per year, especially if this be supplemented by commercial fertilizers. With peat soils, which are extensively used for cabbage growing, the situation may be quite different.

The rotation experiment on the muck soil of the Kankakee Valley in northern Indiana referred to on page 17 showed that while an application of 15 tons per acre of manure gave an average increase in

yield of 2.5 tons per acre, this increase was less than that obtained from an application of 200 pounds per acre of muriate of potash. The value of the cabbage in the field was about \$6 per ton, or a total increase in the value of the crop of \$15 due to the manure. This allowed only \$1 per ton for the manure and the cost of its application. Under such circumstances manure could be more profitably used on mineral soil.

With the recent scarcity and high price of manure it cannot often be used profitably as the sole source of organic matter. To what extent, then, can green manures replace animal manures? Hartwell and Damon (15), working on silt loam in Rhode Island, showed that by turning under a green-manure crop each fall and using 2,200 pounds of a complete fertilizer higher yields of cabbage could be maintained over a period of years than by applying annually about 30 tons of manure alone. Slightly better yields were obtained where 8 tons of manure was used in addition to the green-manure crop and fertilizer. It appears, however, that the quick-growing green-manure crops grown each year were approximately as effective as 10 to 15 tons of manure. Cabbage can be grown without animal manures, but yields cannot be maintained without some form of organic matter.

The choice of a green-manure crop will depend upon the time available for growing it and upon the weather and soil conditions where it is to be grown. A simple rule is to grow that crop as a green-manure crop that will produce the greatest amount of material in the time available. In the more northern States buckwheat, rye, and oats are much used, while to the south crops that require warmer weather, such as cowpeas or soybeans, may be used. When there is sufficient time a legume crop is preferred, because leguminous plants, if inoculated with certain bacteria, can obtain nitrogen from the air, thereby increasing the soil nitrogen when the crop is plowed under. However, a nonlegume is certainly better than no green-manure crop at all.

A few precautions in handling green-manure crops are very important. The crop should be plowed under before it is killed by cold if it is nonhardy. Dead remains of a crop that have been exposed to weathering are of less value than a crop plowed under in the green state. Harter (14), in Virginia, found in two tests that cowpeas, turned under dry in midwinter, were only 65 and 70 percent as effective in increasing cabbage yields the next spring as when they were plowed under green before frost.

A green-manure crop should be turned under before the plants mature and become hard and woody, or tough. Plowing under large quantities of woody or strawy material usually causes a temporary depression in yield of the crops which follow. This happens because the decay of the tough, woody, or strawy material is brought about by micro-organisms in the soil which require large quantities of readily available nitrogen in order to carry on their work. The more old, tough, woody material turned under, the more slowly will it be decayed and the more serious will be the temporary shortage of available nitrogen in the soil. If the plowing under of a green manure is unavoidably delayed until it reaches this undesirable stage, applying 150 to 200 pounds of nitrate of soda, sulfate of ammonia, or ammonium nitrate per acre will hasten decay and lessen later trouble. Under such

circumstances heavier fertilizing of cabbage in the spring with readily available nitrogen is advisable.

The development and maintenance of a good organic-matter content of the soil will do much to reduce the difficulties of drought, leaching, soil acidity, and often other unfavorable soil conditions that are not well understood.

## CROP ROTATION

In order to help hold insects and diseases in check, cabbage should be grown on the same land not oftener than once in 3 or 4 years and preferably at longer periods. It is difficult to plan a 4- or 5-year rotation in the highly specialized trucking sections where comparatively few crops are grown on a large scale, but the rotation should be as long as practicable.

In the Middle Atlantic cabbage districts the following rotations, or similar ones, are practicable:

### EXAMPLE A

*First year.*—Cabbage followed by green manure, followed by fall-planted spinach for winter or early-spring harvest.

*Second year.*—Corn followed by green manure.

*Third year.*—Cucumbers, beets, or squash, followed by fall spinach or beans.

*Fourth year.*—Beans followed by green manure.

### EXAMPLE B

*First year.*—Cabbage followed by green manure, followed by fall spinach.

*Second year.*—Potatoes followed by corn, followed by green manure.

*Third year.*—Sweetpotatoes followed by green manure.

*Fourth year.*—Beans, peas, or cucumbers, followed by green manure.

In the Gulf States, in which spinach is not commonly grown, root crops, such as carrots, beets, or turnips, or other short, cool-season vegetables may be substituted. In general, no specific rotations are followed, since the crops and acreage to be grown depend so much on the current and immediately prospective market conditions. However, an effort is made by the better growers to grow cabbage (or kale or broccoli) on a certain field only once in 3 or 4 years. A common series of crops for a single season is: Early potatoes, corn and soybeans, fall or winter cabbage.

In the northern late-cabbage sections the crop is grown more as a staple farm crop than as a market or truck crop and has a more definite place in a rotation. It is also grown extensively along with canning crops, as:

### EXAMPLE C

*First year.*—Cabbage.

*Second year.*—Sweet corn.

*Third year.*—Peas followed by red clover.

*Fourth year.*—Clover.

### EXAMPLE D

*First year.*—Cabbage.

*Second year.*—Sweet corn.

*Third year.*—Peas followed by white sweetclover.

*Fourth year.*—Tomatoes.



A suggested rotation for northern muck lands follows:

#### EXAMPLE E

*First year.*—Sod or mint (may remain for 2 or more years).

*Second year.*—Corn with soybeans, or potatoes.

*Third year.*—Onions or lettuce.

*Fourth year.*—Cabbage.

In some of the irrigated sections of the West, cabbage is grown in rotation with melons, sugar beets, potatoes, and alfalfa.

Cabbage is a comparatively short season crop, not particularly difficult to handle, is a gross feeder, and so will fit into a wide variety of cropping systems.

### SOIL PREPARATION, CULTIVATION, AND WEED CONTROL

A grower hardly needs to be convinced of the great value of deep, careful plowing and thorough preparation of the soil before transplanting cabbage. It is common knowledge that a deep, firm but friable soil that is free from clods and trash gives a better stand of plants and results in more extensive root development and better early growth than a poorly prepared soil. The matter of cultivation after the plants are established is not so clear.

Extensive studies of the root system of cabbage and of the effect of different systems of cultivation upon root and top growth have been made by Thompson (23) in New York and also by Weaver and Bruner (28) in Nebraska. The results of the work in these widely separated parts of the country agree remarkably well, indicating that the results are generally applicable.

Even when the top of a young cabbage plant is only 5 to 6 inches tall and 8 to 10 inches across, large numbers of roots extend laterally to the middle between the rows and others penetrate to a depth of 2 to 2½ feet. At this time most of the roots are in the upper 12 inches of soil, and many roots are within 2 to 3 inches of the surface. It is obvious that cultivating more than 3 inches deep close to the plants may destroy many roots.

By the time the plants are half-grown, roots entirely fill the space between the rows. In the Nebraska studies, where the plants were grown in deep, mellow, silt loam, few roots of such plants were nearer the surface than 6 inches, and ordinary cultivation to a depth of about 3 inches would therefore do no appreciable harm. On the other hand, in the New York studies where the plants were grown in a gravelly loam containing considerable clay, an appreciable number of roots lay very close to the surface and would have been destroyed by cultivation. The roots of nearly grown plants were found to be very numerous near the surface of the soil even though most of the root system lay between depths of 6 inches and 2 feet.

When cabbage plants are cultivated in the ordinary way there is no danger of root injury in cultivating as deep as 3 inches, close to the plants, while they are still small. After the plants are half-grown, cultivating 3 inches deep will cut off many roots unless the soil has been frequently stirred to that depth, thereby preventing

root growth near the surface. In the Nebraska studies, scraping the soil to a depth of only one-half inch resulted in better growth than cultivation  $3\frac{1}{2}$  inches deep. Deep cultivation prevented root development in the surface 3 inches of soil that makes up a large proportion of the rich topsoil. In the New York experiments (23, 24) shallow cultivation with a hand cultivator and scraping the soil surface with a hoe gave practically the same results.

Deep cultivation (more than 3 inches) during relatively dry weather may result in greater loss of water from the soil during dry weather than does shallow cultivation (1 to 2 inches). The latter is doubtless preferable to scraping on soils which bake very hard, since the loosened and irregular surface will absorb more rainfall.

The experiments here described prove that the main benefit derived from cultivating cabbage is the control of weeds. Weeds must be kept down because they use much of the soil moisture and fertility that are needed by the crop plants. Shallow cultivation, often enough to destroy the weeds, is all that is necessary. Fairly deep cultivation is necessary in working in top dressings of complete fertilizer early in the spring but is likely to be very injurious to the roots later in the season. There is no advantage in cultivating oftener than is necessary to work in fertilizer and to control the weeds.

## COMMERCIALLY GROWN PLANTS FOR TRANSPLANTING

Within recent years the large-scale commercial production of cabbage and other vegetable plants for transplanting has assumed considerable



FIGURE 9.—Shipping container for southern-grown cabbage plants.

importance. Plants grown in the South may be shipped hundreds of miles to those who will grow the crop to maturity (fig. 9). Although the purchase and shipment of such plants may be entirely satisfactory, there are hazards which require special attention if trouble is to be avoided.

As much care should be exercised in choosing a source of plants as in choosing a source of seed. Good plant growers take pride in handling only stocks that are of uniform type, true to name, well-grown, well-packed for shipment, and delivered at the proper time.

Although for the most part the purchase and shipment of such plants are entirely satisfactory, at times they have their disadvantages. Shipments may be delivered during a period of bad weather, making it necessary to hold the plants a few days before they can be transplanted. In such an event the packages of plants should be opened and carefully examined. Any heating of the plants is very injurious and must be prevented by unpacking so that all plants will have free access to the air. If wilting, drying of roots, or yellowing of leaves has started or if the plants must be held more than a day or two before being planted, they should be heeled in in moist soil. Each bunch of plants should be opened and the plants spread out so that the tops have free access to air and light and the roots are in contact with the moist soil.

Losses sometimes occur in transit. It is not often possible for the purchaser to have accurate knowledge beforehand about the plants he is to buy, and as a result he may be disappointed in their size or apparent vigor when they are received. Unless plants shipped North are well-hardened, severe losses from cold may result. Certain diseases may be introduced upon shipped plants unless the producer has taken precautions to keep them disease-free. These dangers and difficulties are mentioned here, not to discourage the practice of buying and shipping plants from a distance, but only so that all possible steps may be taken to insure satisfaction. Many growers prefer to buy plants instead of raising them and are well pleased with the results obtained.

The so-called frostproof cabbage plants that are frequently advertised are plants of the common varieties that have been slowly hardened and subjected to such low temperatures that they will be uninjured by moderate freezing. This resistance to cold is not permanent. If a temporary period of warm weather occurs, the plants lose their hardiness, as described on page 40. After vigorous growth has started, the plants are as susceptible to cold as any other plants of the same variety.

## TRANSPLANTING TO THE FIELD

Hand setting in the field is very widely practiced. In the South and West, where the plants are grown on ridges or on the sides of furrows, machine planters cannot be used satisfactorily. In non-irrigated sections the plants must be firmly set and the soil tightly pressed against the roots; in irrigated sections the plants are merely dropped into the hole made with the dibble, the soil falling about the roots of the plant as the operation is completed. The soil is then settled about the plants by running water to the desired level in the furrows. By this simple procedure an expert plant setter can "stick" about 20,000 plants a day if they are dropped for him at the proper intervals by another worker. In nonirrigated sections where the operation is not so simple, the setting of 6,000 to 8,000 plants is a day's work for a pair of workers.

Horse-drawn or tractor-drawn machine transplanters which supply water to the roots of the plants as they are set are advantageous on soils in the North which are sufficiently level and well prepared to permit their use. Hand setting is also very common, however, because many growers prefer to mark off the rows both ways and plant in

checkrows so that the field can be cultivated both ways, largely eliminating hand hoeing and hand weeding.

Some growers report good results with a small hand-transplanting device which supplies water as the plant is set.

Plants must be set so that moist soil is placed in firm contact with the roots. The plants should be set a little deeper than they stood in the plant bed, so that the "bud," or "crown," of the plant is just high enough above the soil that there is no danger of its being covered. Plants set out in the fall in areas where alternate severe freezing and thawing occur must be set especially firm and fairly deep to avoid being heaved out of the soil.

## CABBAGE CULTURE IN THE SOUTH

### DISTRICTS AND VARIETIES

Cabbage is grown in the South primarily for early shipment to northern markets. The more important districts of production for earliest shipment are in California, Florida, South Carolina, Louisiana, and Texas. Shipments then follow from Alabama, North Carolina, Mississippi, Virginia, Tennessee, and Maryland. In Florida, the Carolinas, Mississippi, and Virginia, the Early Jersey Wakefield, Charleston Wakefield, Golden Acre, and Copenhagen Market varieties are grown, the Wakefields predominating in the districts having the colder winters. Copenhagen Market is most popular in Louisiana and Tennessee; it is extensively grown in Alabama and Texas, but other varieties such as Early Flat Dutch are also important. In California Early Winnigstadt is the leading variety for early shipment.

### GROWING PLANTS FOR TRANSPLANTING

In most of the Southern States, cabbage plants are usually started in beds in the open. It is not possible here to recommend specific dates for the sowing of seed because suitable dates vary widely in different regions and even in different localities not far distant from each other within a general region or State. First-hand experience or at least observation is necessary in determining this very important point. In sowing cabbage in open beds in the fall or winter one must bear in mind the important effects of temperature upon the growth and development of the plants previously discussed.

As is emphasized in the section on diseases, it is important to select an area for a plant bed upon which no cabbage, cauliflower, kale, broccoli, or related plants have been grown recently. A wide variety of soil types is suitable for plant growing, but the soil should be a reasonably mellow one which does not form a hard crust that would prevent or delay the emergence of the seedlings. A soil that packs hard causes too many roots to be broken from the plants as they are pulled for transplanting. An extremely open sandy soil, however, is not best because it tends to become very dry. If the surface soil dries out even for a few days such a delay of germination may result that the young plants will be so small as to winter-kill severely or at least be undesirably small at transplanting time.

If it is necessary to apply fertilizer to the plant bed this should be done several days before the seed is sown unless adequate band-

placement equipment is available for putting it down at planting. The fertilizer should be broadcast after plowing and thoroughly disked or harrowed into the surface 2 or 3 inches of soil. Cabbage seed is especially susceptible to injury by fertilizer. Failure to mix the fertilizer thoroughly into the soil in advance of sowing is practically certain to delay germination, and only a 20- to 50-percent stand may result or the seeds may be killed. If applied in bands, the fertilizer should be placed 1 inch deeper than the seed, under or near the row.

Growers are further cautioned against the use of too rich soil or too much fertilizer in the plant bed. Plants that are forced in growth by excessive fertilizing are usually weak, spindling, soft, and quite unsuitable for transplanting. Studies by Boswell (6) in Maryland showed that many more of the plants fertilized with nitrate of soda were winter-killed than of the plants of the same size that had been fertilized with superphosphate or that had been untreated. A moderate rate of growth on moderately fertile soil should be sought.

In addition to the danger of winter-killing heavily fertilized plants, there is the danger of their becoming so large that they may go to seed. The size of plants should be kept down so that the maximum stem diameter is no greater than that of a lead pencil at the time the plants are to be subjected to cold weather. The grower should have an abundance of plants available so that undersized and oversized plants can be discarded and only the best set in the field.

Seed may be broadcast and lightly covered about one-fourth to one-half inch deep by raking but preferably should be drilled thinly in rows 12 to 16 inches apart. A pound of seed should produce 20,000 plants, which are ample for transplanting 2 acres. A pound of seed so planted will require about 2,500 square feet of bed. On a large scale, seed should be sown at the rate of about 15 pounds per acre of plant bed in 16-inch rows or 25 pounds in 8-inch rows.

In certain sections of the South, particularly eastern Virginia and eastern North Carolina, seed for a late-fall or early-winter crop of cabbage is sown in place in the field. The seed is planted in July or August at the rate of 2 pounds per acre, and the plants are later thinned to a stand. High temperatures in these sections make transplanting generally unsuccessful, thus necessitating the sowing of the seed in the place where the plants are to grow until harvest.

### SOILS

Early cabbage is grown upon different soil types ranging from sandy loams in Virginia, the Carolinas, and Florida to loams in Louisiana, Mississippi, and Texas. Sandy soils are also used to a limited extent in the last three States. Other things being the same, the lighter soils are preferred for an early crop because they are less retentive of moisture and are warmer than heavy soils in mild winter weather and in the spring. They also can be worked to better advantage than heavy soils.

### PREPARATION FOR TRANSPLANTING

The manner of preparing the soil for transplanting cabbage varies greatly in different locations and depends upon the kind of soil, the slope of the land, temperature, and rainfall. In Maryland, Virginia,

and the Carolinas, ridges are generally thrown up 3 feet apart and 10 to 12 inches high a week or two before transplanting time, and the soil is allowed to become firm and settled. The ridges usually lie approximately east and west, and the plants are set 12 to 15 inches apart about halfway up the south side of the ridge where they are protected somewhat from the northerly winds and get the maximum warmth from the sun. In parts of Louisiana and Alabama, the plants are set on top of ridges that are 4 feet apart and 12 to 15 inches high, in order to keep the plants above the waterlogged soil and facilitate drainage. Large areas of good cabbage land are so nearly level and the rainfall is so heavy that the use of such ridges is essential. In irrigated sections the plants are grown on the sides of ridges in order that water may be supplied through the furrows between them. Planting intervals in the row are essentially the same the country over—about 12 to 15 inches for small varieties and 15 to 18 inches for medium-sized varieties.

### MANURE

The value of manure as a source of organic matter has already been discussed (p. 18). Animal manures are satisfactory as sources of the fertilizing elements, nitrogen, phosphorus, and potassium, but these constituents can also be obtained in satisfactory form in commercial fertilizers. On account of the high price and scarcity of manure in most locations, few growers can afford to use it. If it can be obtained nearby for little more than the cost of hauling it to the field and applying it, annual applications of 20 to 30 tons per acre with no commercial fertilizer may give fair yields on the naturally fertile soils in warm regions. However, large quantities of manure alone have not proved to be as profitable as smaller amounts of manure plus commercial fertilizer. In the southern cabbage sections green manures and commercial fertilizers must be depended upon for the most part, as very little manure is available.

Although not strictly applicable, experimental results obtained in the more northern parts of the country should offer valuable guidance. Experiments conducted by the agricultural experiment stations of Rhode Island (15), Ohio (9, 13), Maryland (29), and Pennsylvania (18) all show that 4 or 5 tons of manure per acre, plus commercial fertilizer, is much more profitable than large applications of manure alone (20 to 30 tons per acre). Green manures and plenty of commercial fertilizer must be used if animal manures are not available. Kinds and amounts of fertilizer are recommended in the following section.

### COMMERCIAL FERTILIZERS

In the following discussion of commercial fertilizers it is to be understood that they are to be used in addition to green-manure crops or moderate amounts of manure that are turned under to maintain organic matter. The best results with any amount of commercial fertilizer cannot be obtained on soils seriously deficient in organic matter or on those that are strongly acid. As stated previously, strong acidity should be corrected by lime.

Cabbage is usually grown in the South during the winter or early spring, when the weather during most of the growth period is relatively cool. Fertilizing materials, such as cottonseed meal, tankage,

fish scrap, and manure, which are applied chiefly for their nitrogen, contain this element in a complex form which cannot be taken up by the plants. The nitrogen of these materials becomes available only after certain decompositions occur in the soil, changing the complex nitrogen into usable form. These changes require considerable time and are greatly influenced by the temperature and by the amount of water and air in the soil. They occur very slowly, if at all, when the soil is cold and waterlogged in the winter or early spring, but more rapidly as the soil warms up and is better drained. Because the cabbage plant is able to grow so early in the spring and at such cool temperatures, unless readily available nitrogen is artificially supplied, very little nitrate will be present in the soil and the plant may suffer for lack of it.

The nitrogen in nitrate of soda and ammonium nitrate is immediately available for growth of the plant; so these materials are of especial value in promoting growth early in the season. Nitrate should not be the only source of nitrogen, however, because it is so soluble that it may be leached out by rain and therefore lost before the plant has absorbed it. The nitrogen in sulfate of ammonia is available much more quickly than the nitrogen in organic materials, such as cottonseed meal and tankage; furthermore, sulfate of ammonia does not leach from the soil like nitrate of soda. As the soil warms up, the sulfate of ammonia is changed into nitrates and used by the plants. The organic forms of nitrogen become available to the plants only after some weeks of relatively warm weather.

Thus it would seem that a mixture of nitrate of soda, sulfate of ammonia, and some such material as tankage would afford a fairly steady supply of available nitrogen through the most of the time of the growth of the crop. Experiments have shown this to be true. On sandy types of soil where considerable leaching occurs, the Virginia Truck Experiment Station (31) recommends about a ton per acre of the following mixture: 324 pounds of nitrate of soda, 240 pounds of sulfate of ammonia, 600 pounds of high-grade animal tankage, 636 pounds of superphosphate (16 percent  $P_2O_5$ ), and 200 pounds of muriate of potash. This mixture analyzes approximately  $7\frac{1}{2}$  percent nitrogen, 6 percent phosphoric acid, and 5 percent potash.

Upon heavier soils, which are not so subject to leaching and which warm up a little more slowly, a larger proportion of the nitrogen should be in the more readily available forms. The Virginia Truck Experiment Station (31) recommends for such soils the following mixture: 486 pounds of nitrate of soda, 360 pounds of sulfate of ammonia, 750 pounds of superphosphate (16 percent  $P_2O_5$ ), 200 pounds of muriate of potash, and 204 pounds of filler or conditioner. This mixture analyzes the same as the above, but more of the nitrogen is readily available.

Ware, in Mississippi (27), published results of cabbage fertilizer tests on Ochlockonee loam. Of the many different treatments studied the application of 2,000 pounds of a 4-10-4 fertilizer with the nitrogen in readily available form, as nitrate of soda and sulfate of ammonia, gave the largest and most profitable yields.

In Maryland it is a common practice to use a 7-6-5 fertilizer on early cabbage, the nitrogen being derived from nitrate of soda and sulfate of ammonia.

A very interesting and important point is indicated in these ex-

periments. When sulfate of ammonia was used as the only source of nitrogen in the fertilizer slightly better yields and firmer heads were obtained than when nitrate of soda was the only source of nitrogen; when a combination of the two was used, half and half, the results were still better.

The time and manner of applying the fertilizer to overwintered cabbage are important. Carefully controlled experiments conducted by the Michigan Agricultural Experiment Station by Edmond and Lewis (11) showed very strikingly that a uniform and constant supply of available fertilizing materials must be present through the entire growing period if the best yields are to be obtained. This is especially true with respect to earliness or heavy yields in the first cuttings. A deficiency in plant food that results in a check in growth at any time after transplanting reduces the total yield somewhat and the early yield very greatly.

In areas of light sandy soils where the crop normally makes some growth through the winter and where rapid growth starts very early in the spring, a light application of fertilizer should be made in the fall before transplanting. For such an application the Virginia Truck Experiment Station (31) recommends 500 pounds per acre of a mixture of 800 pounds of tankage or fish, 1,000 pounds of superphosphate, and 200 pounds of muriate of potash. Readily available nitrogen might force too much growth during brief warm periods in the winter, with resultant later cold injury and possibly an increased percentage of seeders in the spring.

It is further recommended that just before growth starts in the spring one-half of the spring application be applied to the south side of the row and immediately cultivated in (fig. 10). The remain-



FIGURE 10.—Field set to cabbage, illustrating method of working in the first application of fertilizer in the spring. Note that only the south side of the ridge is cultivated.



der of this complete fertilizer should be put on the north side of the row and cultivated in when the ridges are worked down level, usually 2 to 3 weeks after the first application.

In addition to the major treatment with complete fertilizer, most growers put on one or two top dressings of 150 to 200 pounds per acre of nitrate of soda before the plants begin to head. These top dressings may or may not be used, depending upon how well the crop is growing. During protracted periods of cool weather or after excessive rainfall the supply of readily available nitrogen in the soil may be diminished to such a point that growth slows down noticeably and the plants take on a yellow color that indicates a need for available nitrogen. Experienced growers can quickly detect such a condition, and it is then that top dressings of nitrate of soda are of much value.

In the lower South nitrate of soda is usually applied 3 and 6 weeks after transplanting, but the time may be varied to suit special cases. In the Middle Atlantic States the first nitrogen application is made early, as mentioned elsewhere, and a second may be made a month to 6 weeks later, but before the heads have formed. The plants are enabled to continue growth under otherwise adverse conditions, and the check in development which has been shown to be so disastrous to high early yields and which also reduces total yields is avoided.

If the plants continue to grow rapidly and uninterruptedly and maintain a strong, luxurious appearance and color, these supplementary applications of nitrate of soda are unnecessary. It should be recalled that excessive quantities of nitrate of soda alone give results less favorable than a mixture of nitrate of soda and sulfate of ammonia. Top dressing of sulfate of ammonia alone during a temporary shortage of available nitrogen in the soil will not produce results as quickly as nitrate of soda. Good judgment and some experience are necessary to get the most profitable results from supplementary fertilizing with nitrogen. Too-early or too-late applications of fertilizer will be wasteful and of little benefit to the plants. If heavy applications are made after heading is well started, the heads may be of inferior firmness.

In the Gulf States, where the winters are so mild that cabbage grows with very little interruption, the applications of fertilizer are made earlier, at such a time that it will be available during the development of the plant. On the lighter soils the first half (about 1,000 pounds) should be worked into the rows thoroughly before transplanting, and the remainder cultivated in about a month later. One-third to one-half of the nitrogen should be supplied by organic materials. On heavier soils, especially in the warmer regions where growth is relatively rapid, the entire amount of complete fertilizer may well be applied before transplanting. Temporary shortages of available soil nitrogen are corrected by applying nitrate of soda and sulfate of ammonia as described in the preceding paragraph.

Broadcast applications of fertilizer may be made with a special broadcast fertilizer or lime distributor and worked into the soil by harrowing and disking. The fertilizer attachment of an ordinary grain drill can be used successfully, and it is often preferred since it permits the placing of the fertilizer at the desired depth of 3 to 4 inches below the surface. If this is followed by harrowing, the material is thoroughly mixed with the top 3 or 4 inches of soil.

For applying fertilizer along the rows or ridges, single-row distributors are generally employed, the fertilizer being applied during the preparation of the row or ridge and thoroughly mixed with the soil in completing the ridge. In all cases it should be well mixed with soil to prevent injury to the plants and to insure its being available to as large a proportion of the roots of the plants as possible. Where plenty of cheap labor is available, many growers make applications in the row by hand. This is a very laborious and under most conditions an inefficient method. More uniform distribution usually can be obtained by machine than by hand.

Top dressing of small plants on ridges is very commonly done by hand, although there are on the market distributors that will place the fertilizer close to the plants or wherever it is desired. After the ridges are worked down such a machine will deliver fertilizer to one side of each of two rows at a time, or along the middles between the rows. Such substantial saving in labor is possible with a good fertilizer distributor that even growers of small acreage should consider its use. It should help to lower the cost of production.

Fertilizer distributors must be thoroughly washed out soon after being used if serious rusting and corrosion are to be avoided. If they are to operate properly, the fertilizer must be free from lumps and in condition to flow with reasonable freedom.

#### HARVESTING AND HANDLING

Cabbage grown in the South for early shipment northward is often harvested as soon as it is large enough to be marketed, even though the heads may not have become hard and fully developed. This is true particularly early in the season when the price is high enough to compensate for the low tonnage harvested. Although the table quality of such immature cabbage is considered quite desirable as soon as it is harvested, the product does not carry as well in shipment as do firmer heads. Unless sold soon after being harvested the heads become decidedly soft from wilting and appear undesirable to the consumer. This often results in limiting the demand, thereby lowering prices. Slight immaturity or lack of firmness is not as objectionable in the Charleston Wakefield and Early Jersey Wakefield as in the round and flat varieties. But even with the pointed types mentioned, care should be taken to avoid harvesting the heads in such an immature condition that they will not stand up in shipment and on the retailer's stand. The very tips of the heads of Early Jersey Wakefield and Charleston Wakefield do not become hard, but they should be well filled and the lower part of the head should be quite firm at harvest. A little experience or first-hand observation is necessary in order to judge accurately the best stage at which to harvest for early shipping.

The round and flat types should be harvested only after the heads have become hard. The outer head leaves of a fully developed head usually are beginning to curl upward and back, over the top of the head. The color of these leaves, too, is distinctly lighter or more yellow green.

A large, heavy butcher knife is the most satisfactory tool for cutting the heads from the rest of the plant. Neat, accurate cuts can be made,

leaving two to four wrapper leaves adhering to the head and necessitating a minimum of later trimming when the heads are graded and packed.

Only heads of similar size should be packed together, and they should be graded to conform to United States grades for cabbage. These grades are subject to revision from time to time and so are not presented here. Copies of the standard grade specifications may be obtained free of charge by writing to the Office of Distribution, War Food Administration, Washington 25, D. C.

Shipments are made in a variety of containers, but one certain type is usually standard within a single cabbage-shipping region. Obviously, the grower must familiarize himself with the packing requirements of the markets in which he intends to sell. This information can be obtained from local growers, shippers, and buyers or from the publications discussed in the next paragraph.

The preparation for market and marketing of cabbage are discussed fully in two publications of this Department. Technical Bulletin No. 646, *Marketing Commercial Cabbage (22)*, is designed more for the dealer, the shipper, or the grower-shipper who requires information on market requirements, marketing practices, and movements of shipments over the whole country. *Farmers' Bulletin No. 1423, Preparation of Cabbage for Market (16)*, is primarily for the grower; it discusses the harvesting, grading, packing, types of packages, methods of loading cars, and the Government inspection of cabbage.

## CABBAGE CULTURE IN THE MIDDLE AND NORTHERN STATES

The following discussion will apply, with the exceptions noted, in those States lying north of a line which passes approximately along the northern boundaries of North Carolina, Tennessee, Arkansas, Oklahoma, New Mexico, and Arizona. The area in proximity to Chesapeake Bay, although north of this arbitrary line, has climatic features that are more typically southern. The same is true of certain parts of California. On the other hand, there are regions of high altitude in the Southern States where the climate is characteristic of the country much farther north but at lower elevation above sea level. Because of differences in temperature, length of growing season, and market demands, cabbage culture in the Northern States presents very different problems from the culture in the South, although the principles underlying successful growing are the same.

### DISTRICTS AND VARIETIES

The most important of the northern cabbage-growing districts are in western and central New York; in the portions of Wisconsin, Ohio, and Michigan lying near the Great Lakes and of Wisconsin, Minnesota, and Iowa lying near the Mississippi River; and in north-central Colorado. However, important commercial acreages are found in many other States.

The greater portion of the crop of the Northern States is composed of midseason and late varieties, although the early varieties are extensively grown. Early Jersey Wakefield and Charleston Wake-

field are grown for home use and early local markets but are relatively unimportant. Copenhagen Market is extensively grown in the Middle West and in Colorado for both market and sauerkraut. Glory of Enkhuizen is very popular as a market and sauerkraut variety in the more northern States. Danish Ballhead and Wisconsin Hollander are extensively grown for storage, and All Seasons is grown widely for sauerkraut. Only the Danish type can be successfully stored for long periods.

## EARLY-MARKET CROP

### EFFECTS OF TRANSPLANTING

Differences of opinion exist among gardeners as to the best practices in growing plants for setting in the field. Some sow the seed in the plant beds and never move the plants until they are taken from the bed and placed in the field; others maintain that taking up the seedlings and transplanting them to flats, to other parts of the bed, or to other beds is better; a few transplant even a second time before placing the plants in the field.

Studies of transplanting cabbage by Loomis (17) at the agricultural experiment station of Cornell University show that in itself transplanting is not a benefit to the plant, but, on the contrary, tends to stunt it somewhat. Considered from a practical field standpoint, however, the transplanting of plants in the beds before they were set in the field was without any appreciable effect upon earliness or yield. A very important fact must be borne in mind in considering these experiments and in applying the results to practical conditions. All plants, regardless of the number of times they were transplanted, had the same amount of space in which to grow.

Three lots of seeds, for example, were sown in ground beds and the seeds spaced far enough apart so that the plants could grow until ready for the field without crowding each other. The first of these lots of plants was not taken up until it was moved to the field. Two lots were taken up in the small seedling stage and reset at the same spacings at which all lots were originally sown. When the plants were  $2\frac{1}{2}$  to 3 inches high one of the lots that already had been transplanted once was taken up and reset at the same spacing a second time. Then all three lots were allowed to grow until set in the field. Even though the transplanting had a temporary stunting effect they all made practically the same growth and yield in the field.

It is common knowledge that taking up a small plant breaks off many small roots and that after it is reset it soon develops a more bunchy root system than if the transplanting had not been done. At the same time the plant has been actually stunted in growth. These experiments, repeated with several lots of plants each year for 3 years, show that there is no advantage in stunting the young cabbage plant in order to get more bunchy roots for setting in the field.

The only reason young cabbage plants ever need to be transplanted in the beds or greenhouse before being taken to the field is to give them more space in which to grow. Seed is sown thickly as a matter of convenience, in order that the size of the seedbed need not be large, that good care may be given to the seedlings, and that there may be less loss of seedlings and a saving in the amount of seed to be sown. This thick sowing results in crowding that makes the plants spindling

and stunts them far more than transplanting. Consequently they are transplanted to give each plant space in which to spread its leaves and to afford an adequate volume of soil for the roots.

In growing hotbed plants on a limited scale there is much to recommend thin sowing and leaving the plants in place. If the small plants are pricked out, or spotted, into other hotbeds or into coldframes it is necessary to work in the open, perhaps in unfavorable weather, with great discomfort to the workmen, a loss of efficiency, and also with some hazard to the plants. The weather may even be so severe as to prevent spotting being done at the proper time and a loss of seedlings or the production of inferior plants for setting in the field results. Sowing about three-eighths ounce of seed per sash in rows from 4 to 4½ inches apart, followed by some thinning out of the weaker plants, should leave 1,000 to 1,100 good, strong plants per sash. This is approximately the number that would be spotted in the same area at 1½ by 1½ inches, and the plants can be grown with less expense and less hazard of loss or damage. This method obviously requires much more extensive hotbed facilities than if the plants are only started in hotbeds and then transplanted to coldframes. The scarcity of manure may necessitate the use of other means of heating the beds.

The experiments at Cornell University referred to above also showed very strikingly the increase in the stunting effect of transplanting upon plants progressively larger in size. If plants are to be spotted or otherwise transplanted before being taken to the field, this should be done just before the first true leaf unfolds from the bud between the two seed leaves, or cotyledons. It is especially important that seedlings standing very thickly be pricked out promptly lest they become tall and spindling and difficult to spot without breaking. Furthermore, a disease called damping-off attacks the seedlings more seriously when they are crowded in the seedling row.

#### GROWING PLANTS FOR TRANSPLANTING

In the Northern States, where the winters are too severe for overwintering cabbage plants in the open, fall-grown plants can be overwintered in coldframes and set in the field early in the spring, but it is not a very common practice. The production of plants of proper size in the fall and carrying them over winter are both attended by considerable hazard on account of unpredictable and severe weather conditions. Generally such overwintered plants are not enough earlier than spring-grown plants to justify the hazard and the expense of producing and carrying them over winter.

In growing spring plants for an early-market crop in the North it is necessary to start them under glass very early in the spring. Greenhouses or sash greenhouses are the best plant-growing structures, but standard greenhouses are too costly to use for early-plant growing alone, although they can be used profitably for this purpose if used for the growing of other crops at other seasons of the year. As the greenhouse operator who may wish to grow some early cabbage is doubtless already familiar with the fundamental operations in producing plants of many kinds, no space need be devoted here to the elementary steps of growing cabbage plants in greenhouses. The construction and management of greenhouses and sash greenhouses is too large a subject and too highly specialized to be included in this circular, but information

on that subject may be found in *Farmers' Bulletin 1318, Greenhouse Construction and Heating (3)*. However, attention may well be given to the construction and use of hotbeds and coldframes for growing cabbage plants.

#### LOCATION OF HOTBEDS AND COLDFRAMES

Hotbeds and coldframes should be conveniently located so that they can easily be given the close attention they require. They should be in a place protected from cold winds by buildings, hedges, or other barriers; they should be on a well-drained, slight slope, preferably to the south or east, and where they can be easily watered when necessary.

#### MATERIALS

Experiments conducted by Comin and Sherman (10) in Ohio have shown that for growing cabbage plants glass is a better cover for hotbeds or coldframes than any substitute that has been devised. The substitutes are much lighter and easier to handle than glass, but they have some shading effect upon the plants and are not quite so effective in developing and maintaining satisfactory temperatures in the beds. The substitutes that are lower priced than glass are so short-lived that in the long run they are no cheaper. Those substitutes which do have good lasting qualities are, at this writing (1945), too expensive to replace glass satisfactorily. Furthermore, cabbage plants grown under common glass are larger and more vigorous at transplanting time and produce larger early and total yields than plants grown under any substitute. Earliness is a very important factor in the early-market crop, and a reasonable expense in producing plants is justified in order to attain it.

Many questions have been asked about the special value of those kinds of glass which transmit the ultraviolet rays of sunlight and whether there are particular advantages or dangers attending their use in growing plants. Extensive studies at various institutions (1, 2, 12) indicate that the ultraviolet rays of sunlight have no appreciable effect on the size, form, or rate of growth of plants. Experiments carried on by the United States Department of Agriculture (7) show that common glass is quite as good for growing a variety of vegetable plants in coldframes as are the various kinds of glass that transmit ultraviolet rays. The ultraviolet glasses appear entirely satisfactory, however, their only probable disadvantage being their higher price.

Muslin is widely used as a coldframe cover for growing certain plants, but it is not recommended for hotbeds for starting early cabbage in the more northern States because the plants must be started early while the weather is still so cold that muslin is not satisfactory.

Standard sash can be obtained glazed and painted complete for \$3 to \$4 each, depending on details of construction, quality of materials, and the distance they must be shipped. Sash can also be obtained painted but unglazed or unpainted and unglazed, the painting and glazing to be done by the buyer. If the cost of labor is considered, there is but little, if any, saving in buying unpainted, unglazed sash. Of course, if glazing and painting can be worked in along with other winter work for little or no additional outlay of money, it may pay to purchase the incomplete sash.

Sash with lapped glass is preferred to that with butted glass for hotbeds, but for coldframes butted glass is considered satisfactory. Butted glass usually leaks a little, and it is more difficult to replace broken panes than if the glass is lapped. Sash with three rows of 10-inch panes is better than that with four or more rows of smaller panes, because there are fewer bars which cut off part of the light. On the other hand, as breakage of large panes is more expensive than that of small panes, if the sash is not carefully handled, the cost of maintenance will be a little higher.

The frames should be built of rot-resisting wood, such as cypress or redwood, which will last several years. Pine boards rot very quickly and are rarely good for more than one or two seasons. Permanent beds may be built with brick or concrete walls.

In areas of mild climate where only slight protection of the plants is needed muslin is successfully used as a cover for both hotbeds and coldframes. If there is any doubt about its adaptability to specific conditions and requirements, a careful comparison on a limited scale with glass should be made before depending upon it entirely.

#### CONSTRUCTION OF MANURE-HEATED BEDS

The most satisfactory size of bed is one that will be exactly fitted by any desired number of standard sash. Standard sash are 6 feet long and 3 feet wide; so the bed should be 5 feet 10 inches wide, outside measurement, and any convenient length.

In the milder parts of the Northern States a manure-heated bed may be constructed entirely on top of the ground (fig. 11). A flat, well-packed pile of heating manure, about 9 to 10 feet wide, 3 to 4 feet longer than the frame to be used, and 18 inches to 2 feet high, is prepared. The frame is then set on the center of this pile of manure, soil placed in the frame, the sash put on, and the outside of the frame



FIGURE 11.—Hotbeds constructed on a flat, low pile of manure.

well banked with manure. This procedure saves the labor of digging a pit, but requires considerably more manure and is not suitable in very cold areas.

Shortly before the construction of the bed is started an adequate supply of fresh horse manure should be uniformly and compactly piled near the location of the bed. When the manure first starts to heat it should be mixed and repiled. Two or three days later the pit

for the manure should be dug<sup>5</sup> and the manure placed in it as follows: The pit should be 7 feet wide, a foot longer than the frame, and 2 to 2½ feet deep. The farther north and the colder the weather the deeper the pit should be, so as to hold more manure for furnishing more heat. The warmest part of the pile of manure should be placed in the bottom of the pit, and that which is cooler near the top. Successive layers of 3 or 4 inches of manure should be spread in the pit and thoroughly tramped down before more is added. If the manure tends to be dry, a sprinkling can of water should be added to each 2 or 3 linear feet of bed to prevent the manure from burning. After 18 inches to 2 feet of manure have been thoroughly packed in and leveled across the top, the frame should be put in place, the manure extending 6 inches beyond the wall of the frame on all sides; then 4 or 5 inches of moist, rich, light, disease-free garden soil may be placed on top of the manure within the frame, the frame covered with sash, and the outside of the frame well banked with manure and soil in order to retain the heat. The front of the frame should be 6 to 8 inches above the soil and the back 12 to 14 inches high.

Steam-heated or hot-water heated beds (figs. 12 and 13) are replacing manure-heated beds in many localities where large quantities of plants are needed and where the manure supply is inadequate or expensive. Satisfactory results have been obtained with electrically heated beds in localities where current can be purchased below 3 cents per kilowatt-hour. The first cost of beds of these types is appreciably more than that of manure-heated beds, but subsequent labor and maintenance costs are less, because they do not have to be constructed new every year. The construction of pipe-heated beds is a subject requiring more attention than can be devoted to it in this circular. Growers who are especially interested in constructing such beds should write to their own State agricultural experiment station or to the United States Department of Agriculture for information.

#### CONSTRUCTION OF COLDFRAMES

Coldframes are constructed essentially the same as hotbeds, except that they are usually less permanent and no artificial heat is provided. The sun is the only source of heat, and the glass or other cover is designed to retain the accumulated heat sufficiently to promote growth and protect the plants from frost during occasional brief periods of cold weather. Coldframes will not long maintain temperatures high enough for growth or even above freezing when the outside temperature is much below freezing. Temperatures remain low during periods of cloudy weather.

The frames and sash described for hotbeds may be set directly on the surface of a well-prepared soil, thereby serving as a coldframe. Generally, however, coldframes are constructed upon a much more extensive scale than hotbeds. Since they are not used during the summer, they are built so they can be dismantled easily and stored away so the land can be used for other purposes (fig. 14).

<sup>5</sup> In the more northern locations where the soil is usually deeply frozen at the time for constructing the hotbed, the pit may be dug the preceding fall and filled with cornstalks or straw, or covered in some convenient way to prevent the accumulation of ice in the pit. The coarse filling material can be easily removed, avoiding the difficulty of digging in frozen soil. The soil for the beds should be protected from freezing by covering the pile with manure or similar material.



A knock-down type of frame that is very extensively used is built simply of two parallel lines of boards, firmly supported on edge by stakes driven into the soil, and with boards across the ends to complete the enclosure. The frames generally lie east and west, with a 12-inch board forming the back (north side) and a 6-inch board in front (south

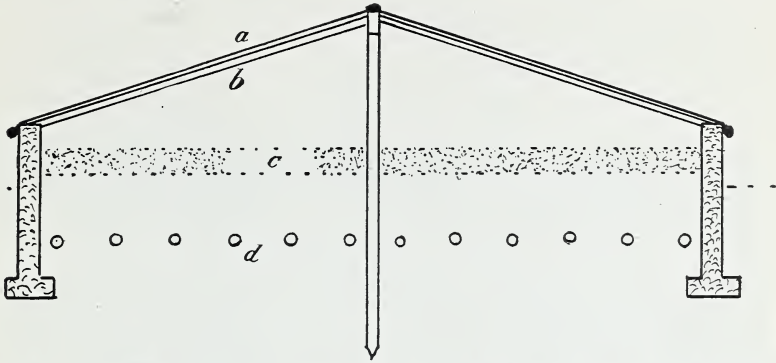


FIGURE 12.—Cross section of pipe-heated bed with pipes buried in the soil, heat being supplied from a boiler: *a*, Canvas or muslin cover; *b*, crosspieces supporting cover; *c*, special soil; *d*, heater pipes. Width of bed, about 12 feet.

side). If standard sash are to be used, the back and front boards are 5 feet 10 inches apart and have no pieces connecting them across the top.

If cloth covers are to be used, the beds may be as much as 7 or 8 feet wide (fig. 14). In this event, the back board should be 15 to 18 inches high to give adequate slope to the cover. Light crosspieces

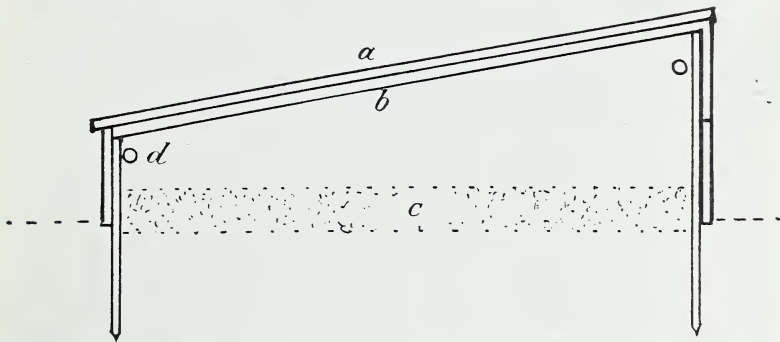


FIGURE 13.—Cross section of frame provided with two lines of heater pipes for use in case of low outside temperature: *a*, Glazed sash; *b*, crosspieces to support sash; *c*, special soil; *d*, heater pipes. Outside width of bed, 5 feet 10 inches.

connecting the front and back boards are necessary every 3 or 4 feet to keep the cloth from sagging down on the plants and to facilitate rolling back the cloth when the beds are uncovered. Cloth-covered frames are also built 12 to 14 feet wide, with both lines of boards only 6 to 8 inches high and a ridge along the middle, about 2 feet high, supported on stakes (fig. 15). The muslin is firmly held to the ridge or high north side by nailing laths over one edge of the muslin; it is then stretched over the bed and held at the lower sides by the weight of poles or strips of wood fastened to the edge of

the cloth or held inside a hem. The cloth is held over the endpieces of the bed by loops of cord hooked over nails.



FIGURE 14.—Muslin-covered coldframes. Note the pipe for supplying water.



FIGURE 15.—Muslin cover of a 12-foot frame rolled up to center ridge.

There are methods of treating cloth to make it waterproof, but these treatments are of questionable advantage. If a good grade of muslin is used and it is thoroughly dried before being put away after use each season, it should last for many seasons. Untreated cloth is lighter, more pliable, and easier to handle than treated cloth.

#### MANAGEMENT OF HOTBEDS AND COLDFRAMES

The temperature of the soil should be determined with a dependable thermometer. Two or three days after the manure hotbed is

made the temperature may rise to 90° F. or higher. The seed should not be planted until the temperature subsides to about 80° to 85°; this is usually 2 or 3 days later. After this time, a moderate heat, about 65° to 75°, should be maintained for several weeks. If the bed is heated by flues or pipes, the temperature can be controlled at will and planting may be done whenever it is desired.

The principles governing proper management of hotbeds are the same for all kinds, except that the temperature of manure-heated beds must be controlled entirely by manipulation of the sash and covers, whereas in flue-heated or pipe-heated beds the source of heat can be controlled. Keeping the proper temperature is but one of the very important things that can be learned thoroughly only by experience.

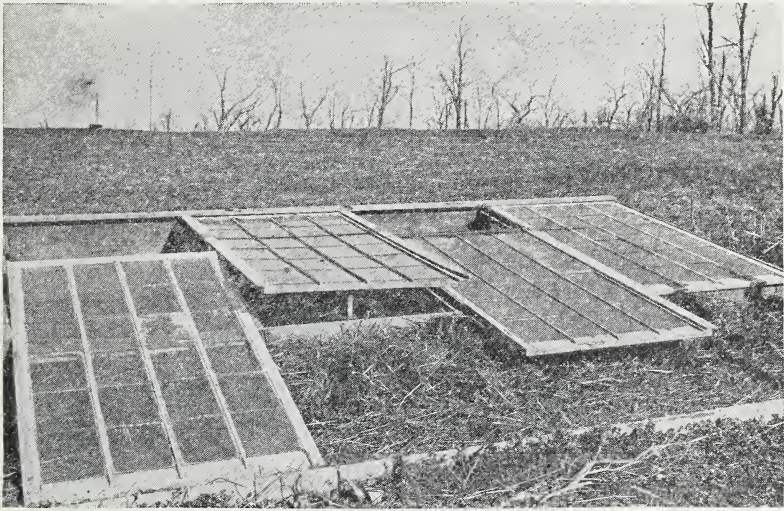


FIGURE 16.—Ventilating hotbeds by partly removing the sashes or propping them up.

Beds should be watered only in bright weather, preferably in the morning, when it is warm enough to leave the covers off for a few hours so that the water will dry off the plants and the surface of the soil before the covers need to be replaced. Excess water on plants or soil is conducive to the spread of disease, as is also an excessive humidity of the air within the bed. The proper watering of plants requires more judgment and skill than an inexperienced person would suppose. There is more danger of watering too much than too little. Good soakings of the soil at longer intervals are better than frequent light waterings because the latter wet the plants and soil surface too often. Insufficient water obviously checks the growth.

Ventilation is another matter requiring some experience and good judgment in order to be properly done. Varying numbers of sash may be raised slightly at the lower edge or at the side at intervals along the bed, as required, and held open by notched boards or any convenient support (fig. 16). With increasing outside temperature the sash must be opened more. In windy weather the openings should be smaller and fewer than on quiet days, and the openings should be to the leeward so that strong drafts will not sweep over the plants.

Muslin covers need to be opened less frequently than glass ones because some ventilation takes place through the cloth. Varying amounts of ventilation are given by rolling up the cover the required distance from the lower edge.

When outside temperatures much below freezing are liable to occur, the glass or cloth covers should be further covered with hotbed mats, straw, pine needles, or similar material. Sash, other covers, or straw can be kept from blowing off the beds by laying heavy boards or poles across them or by stretching stout wires lengthwise of the beds, fastening them securely to stakes at the ends.

The management of coldframes is essentially the same as that of hotbeds except that coldframes require a little less attention during the day and may require more extra covering in cold weather. The absence of artificial heat is mainly responsible for this difference.

#### SOWING SEED AND SPOTTING PLANTS

In general, seed should be sown about 7 weeks before time for transplanting to the field. The seed should be sown thinly, about 3 to 4 seeds per inch, in rows about 4 to 4½ inches apart, and covered about one-fourth inch deep. Sown at this rate a pound of seed will plant 35 to 40 sash and, under proper conditions, produce about 38,000 to 40,000 plants suitable for transplanting. Stated another way, it requires a little less than one-half ounce of seed per sash, and this should give at least 1,000 suitable plants. Considerable allowance for loss and some thinning has been made in these calculations. By sowing more thinly, so that there is less crowding and all plants have a better chance to develop fully, a pound of seed will furnish plants for 4 acres, but it is safer to sow a pound for each 3 acres and then pull out the weaker plants and thin down bunches of plants that stand too thick for good development.

If prospects of fancy prices for extra-early cabbage justify special efforts to produce large plants (6 to 8 inches high) for setting in the field, then spotting the plants about 3 by 3 inches would doubtless be more practicable. Attempting to sow thinly and subsequently further thinning the plants to such a spacing (250 to 300 plants per sash) would be too extravagant of seed and labor. Furthermore, such plants had better be produced in a greenhouse or sash greenhouse.

#### HARDENING OFF PLANTS

It is best to maintain an uninterrupted, moderate rate of growth until the plants are nearly large enough to set in the field (about 4 inches high). They should reach this particular size about 10 days before time for transplanting; during these last 10 days growth should be slowed down by gradually exposing the plants to lower and lower temperatures and also by gradually withholding water, taking care to avoid wilting the plants or allowing them to be damaged by cold. Some experience is necessary to accomplish this properly. Once the plants are hardened off, care should be taken to keep them so until they are set in the field. Recurring high temperature or high moisture content that would stimulate growth may result in the hardiness being lost. Hardy plants will become tender again in about the same length of time required to harden them off if they are subjected to conditions suitable for growth.

This process of checking growth hardens the plants, making them resistant to cold, somewhat resistant to wilting, and better able to withstand the shock of being transplanted to the field. New roots form more quickly on hardened plants, and vigorous growth is resumed sooner. These desirable effects upon growth are of quite as much importance as cold resistance. The leaves of a well-hardened plant are thicker and stiffer and have a heavier bloom than those of a nonhardened, or tender, plant. A tinge of red may develop at the edges of the leaves and along the stems. The stems are stockier, thicker, and firmer.

#### SOILS

There is less variation in the classes of soil suitable for growing the early-market cabbage crop in the North than for growing cabbage in the South. On account of the relative earliness in the spring when the plants are set in the field, it is of primary importance that an "early" piece of land be used. Light or medium-light soils such as sandy soils or sandy loams are distinctly better than heavier soils such as loams or clay loams. The lighter soils are usually better drained and, because of lower water content, can be worked earlier and are definitely warmer than a heavy soil that retains large quantities of water.

#### MANURE

Comin and Bushnell (9) and Gourley and Magruder (13) in Ohio and Hartwell and Damon (15) in Rhode Island have shown that large applications of stable manure alone (16 to 30 tons per acre) produced smaller and less profitable yields than applications of 1,200 to 1,800 pounds of a high-grade complete fertilizer together with green-manure crops. The complete fertilizer used in the Ohio experiments was a 4-10-4 and that in the Rhode Island experiments an 8-12-4.<sup>6</sup> The best yields in both places were obtained from manure plus commercial fertilizer plus green-manure crops. In Rhode Island 5 to 8 tons of manure plus fertilizer was better than 30 tons of manure alone. In Ohio 16 tons of manure plus complete fertilizer plus green manure was but very little better than complete fertilizer and green manure. There was, therefore, but little return from the manure in this combination. Four or five tons probably would have been more profitable.

In studying the amounts of fertilizer and manure required for several crops, including cabbage, over a period of 13 years, White and Boswell (29) in Maryland obtained results in agreement with those discussed above. The highest yields of cabbage were obtained with 1,500 pounds of complete fertilizer and with 6 tons of manure plus 750 pounds of fertilizer. The latter treatment gave but little higher yields than 1,500 pounds of fertilizer and cost more to apply. The final net money value is slightly in favor of 1,500 pounds of fertilizer. Twelve tons of manure annually produced high yields, but the cost made it the least profitable treatment. Even though as light applications as 2 tons of manure plus 250 pounds of fertilizer produced low yields, the increase in net value above that of untreated plots was greater than the increase when 12 tons of manure was used.

<sup>6</sup> 8 percent nitrogen, 12 percent phosphoric acid, 4 percent potash.

Experiments conducted by Mack (18) in Pennsylvania showed that, over a period of 10 years, 1,200 pounds of 5-8-7 fertilizer produced higher yields than 20 tons of manure.

Although these four experiments were carried out under widely different conditions, these general conclusions should hold: The net value of small quantities of manure (4 to 6 tons per acre per year) plus commercial fertilizer is clearly greater than large quantities of manure (16 to 30 tons) alone. Green-manure crops and plenty of commercial fertilizer must of course be used. Good yields of cabbage can be built up and maintained profitably without animal manures. If manure is available it can be used most profitably in moderate quantities, supplemented with commercial fertilizer.

#### COMMERCIAL FERTILIZERS

The analyses of the fertilizers used in the Northern States tend to be a little lower in nitrogen than those used in the South and range from a 5-8-5 or 5-8-7 on the heavier or warmer soils to a 7-6-5 on lighter soils and in regions of late cool weather where an abundance of available nitrogen needs to be supplied. Experiments in widely separated places are consistent in showing the need for a complete fertilizer and that complete fertilizer with cover crops or with small amounts (4 to 5 tons) of manure is much more profitable than large quantities (20 to 30 tons) of manure alone.

Exact analyses cannot be recommended because requirements vary in different localities. It should be said, however, that changes of only 1 percent in the analysis of a fertilizer are hardly worth while in making practical trials. If cabbage grown with 1,000 to 1,200 pounds of a 4-8-4 or 5-10-5 fertilizer shows a need for more nitrogen, as indicated by poor color, a change should be made to a 7-8-5 fertilizer at least, or the basic application may be supplemented by top dressings of nitrate of soda and sulfate of ammonia, as described on page 29. About 1,200 to 1,500 pounds of complete fertilizer per acre is usually adequate if supplemented with successive applications of 150 to 200 pounds of a mixture of nitrate of soda and sulfate of ammonia as needed.

In the North the complete fertilizer is usually all applied just before transplanting. Quantities up to 1,000 pounds per acre may be applied in a broad strip and thoroughly mixed with the soil where the rows are to be. If more than 1,000 pounds per acre is to be applied, the amount in excess of 1,000 pounds should be broadcast unless a total of a ton or more is to be used, when the entire amount should be broadcast. Broadcast applications should be made after plowing but before disking or harrowing, in order to mix the fertilizer thoroughly with the soil as deeply as possible.

A discussion of the methods of applying fertilizers is given on page 26.

#### HARVESTING AND HANDLING

The methods of harvesting and handling the early crop in the North are essentially the same as for the crop in the South (p. 30). In general, however, the northern crop is shipped shorter distances, and a much larger proportion of it is marketed locally.

## LATE, OR MAIN-CROP, CABBAGE

## GROWING PLANTS FOR TRANSPLANTING

Plants for the late, or main, crop are grown in beds in the open essentially as described for the South (p. 24) except that the seed is sown in the late spring or early summer instead of in the fall. Recommendations made with reference to fertility of the plant bed in the South apply here as well, although there is no danger from winter injury or from premature flower-stalk formation. Plants grown very rapidly may be spindling and too tender to stand well the shock of transplanting. Plants grown at a moderate rate, which are stocky and firm, will not wilt so badly upon transplanting as will very rapidly grown plants. Well-grown plants also produce new roots and start growth in the field more quickly.

Seed should be sown 5 to 6 weeks before time for transplanting in the field. Open plant beds are satisfactory if the cabbage maggot is generally absent. In areas where this insect is prevalent, the plant beds may be kept covered with cheesecloth to prevent the adult insect laying eggs near the young plants. (See Cabbage Maggot, p. 55.) Frames may be constructed like coldframes and placed over the beds after the seed is sown. Cheesecloth with 20 to 30 threads per inch makes a satisfactory cover. This gives some shading and causes the plants to be a bit more soft and succulent than when grown in the open. The cloth should be removed from the bed 6 to 10 days before pulling so that the plants will become somewhat hardened.

Experiments by Myers (20) in Pennsylvania showed that the largest plants in the plant bed produced the highest yields of late cabbage. The approximate yields per acre produced by plants of different sizes were as follows: Large, 21 tons; medium, 18 tons; small, 13 tons; ungraded plants, or run of the bed, 18 tons. Therefore, for the late crop it appears worth while to discard the small plants. Some excess of plants should be grown to insure an ample supply, and only the plants of medium or large size should be transplanted.

## SOILS

Since most of the growth of the late crop of cabbage must be made during the summer, when rainfall is often light and there is danger of drought, the heavier types of soils such as loams and clay loams are best. These soils retain moisture better than light soils and support growth better through the somewhat dry summer months. Another reason for the preference for loams and clay loams is their superior fertility. Early cabbage is usually of comparatively high value, while the late product brings lower prices. At high prices for the early crop, a grower is justified in using the very large quantities of fertilizer needed on some of the light, poor soils that have the physical characteristics necessary for earliness. But profitable yields of late cabbage might not be, and usually are not, produced on such soils. Production costs per ton must be kept down.

Late cabbage is grown on muck soils to a considerable extent.

## MANURES AND FERTILIZERS

Recommendations upon the use of manure for the early crop (pp. 41 and 42) hold equally well for the late, or main, crop. As a

matter of fact, most of the experimental evidence concerning the value of manure on cabbage has been obtained in connection with the main crop.

Whereas nitrogen is the most needed constituent in early-crop fertilizers, experiments on later cabbage have shown that only moderate amounts are required. No effort is made to force the late crop into such rapid growth as the early crop; furthermore, during the growing season of the late crop the soil is warmer and better aerated and so contains more available nitrogen than it does early in the spring.

Late, or main-crop, cabbage is grown on soils of generally higher natural fertility than much of the early-market crop and in a rotation in which considerable organic matter is turned under. Consequently, less nitrogen needs to be applied in commercial form. Mack (18) in Pennsylvania has shown phosphorus to be of great value. Fertilizer recommendations for various parts of the country are in general agreement. It is assumed that a reasonable supply of organic matter will be maintained in the soil by manuring, by turning under green manure crops, or by both.

A 4-12-4 or 5-10-5 fertilizer is satisfactory in most instances. On slightly lighter soils a 7-6-5 should be used; but soils requiring such treatment are not the most satisfactory. On the more fertile soils 600 to 1,000 pounds are commonly used and 1,000 to 1,500 on the less fertile. Early in the season a top dressing of 150 to 200 pounds of a half-and-half mixture of nitrate of soda and sulfate of ammonia should be given if the plants do not start growth satisfactorily. In dairy regions where plenty of manure is used, 500 to 600 pounds of 16-percent superphosphate may be the only additional fertilizer required.

On newly developed muck lands manure usually gives a substantial increase in yield for the first few years. Later, however, the benefits of manure alone are less pronounced. Experiments carried on by the United States Department of Agriculture<sup>7</sup> on new muck at North Liberty, Ind., showed an 8-ton increase in yield of cabbage from applying 15 tons of manure per year. On old muck near South Bend a similar amount of manure gave yield increases of only 2.5 tons. In the former experiment, 200 pounds of muriate of potash gave practically the same yield as the manure, while at South Bend the potash plots yielded slightly more than the manure. Considering the relative cost of manure and of potash, the latter is usually the more profitable to use.

Experimental results obtained with fertilizers on muck soils by the United States Department of Agriculture have been confirmed by extensive experience. On such soils, cabbage requires a fertilizer relatively low in nitrogen but high in phosphorus and potash. Potash seems to be the required fertilizing element most deficient in muck soils. An 0-10-16 fertilizer is widely used and gives good results. A mixture of approximately this ratio is readily made from 800 pounds of 20-percent superphosphate and 400 pounds of muriate of potash. If results show the need for nitrogen, 100 pounds each of nitrate of soda and sulfate of ammonia may be added to this mixture, or the two may be mixed and used as a top dressing. If

<sup>7</sup> Unpublished.



they are included with the superphosphate and potash, approximately a 2½-9-15 mixture is obtained.

It should be emphasized that the individual grower must carefully note his results with various fertilizers and add more of whatever materials appear to be lacking. In some instances 4 to 5 percent of nitrogen is needed in mixtures otherwise similar to those recommended above. It is not possible to make recommendations that will be best for all muck soils.

Complete fertilizers may be applied to the soil broadcast after plowing but before disking or harrowing. If applied on the surface with a row distributor, the fertilizer must be thoroughly mixed with the soil as deeply as possible before planting. Most of the roots of the cabbage lie between 3 and 12 inches below the surface, and obviously the fertilizer should be where the roots will reach it.

#### HARVESTING AND HANDLING

Late cabbage is harvested only after the heads have become hard. Generally, the heads should be trimmed rather closely, to three or four tight wrapper leaves, this trimming being done as the cabbage is cut in the field. The heads are usually hauled in bulk from the field to market, to the storage house, or to the sauerkraut factory. Precautions should be taken to prevent unnecessarily rough handling and bruising of the product, since damage may result in serious spoilage. Rough handling at least mars the appearance of the heads.

#### CABBAGE FOR SAUERKRAUT

The varieties most commonly used for sauerkraut are Glory of Enkhuizen, Late Flat Dutch, All Seasons, and in some sections Copenhagen Market. These varieties are of the so-called domestic type, which becomes moderately hard but cannot be successfully stored. Danish Ballhead and Wisconsin Hollander are of the Danish type, which is rarely used for sauerkraut.

When cabbage is harvested for immediate delivery to the sauerkraut factory, it should be trimmed closely by removing all loose and wrapper leaves. It must be fully developed or mature. Green cabbage produces sauerkraut which is offgrade in color and texture.

#### STORAGE

Danish Ballhead is the variety grown for storage except in areas which are infested with cabbage yellows, where Wisconsin Hollander or Wisconsin Ballhead may replace it. The last-named variety is similar to Danish Ballhead (p. 15) but is resistant to cabbage yellows.

To be successfully stored, cabbage must be quite free from disease (see p. 50) of any kind and should be reasonably free from mechanical or insect injury. All loose leaves should be removed. It should be stored at a temperature of 33° to 35° F. and a relative humidity of 90 to 95 percent. As cabbage freezes between 31° and 31.5°, the temperature of the storage house should not be allowed to fall below 32° for more than a few hours and preferably not at all. Mild freezing is not particularly destructive, but it should be avoided, especially in storage-house or cellar storage.

#### COMMERCIAL STORAGE

The most satisfactory storage conditions are afforded by specially constructed, frostproof storage houses (fig. 17), and it is in such



FIGURE 17.—Exterior of a satisfactory type of cabbage storage house.

structures that most of the commercially stored cabbage is held. Large quantities are also held in commercial cold-storage rooms.

The best type of cabbage storage house is of well-insulated, practically frostproof construction. The roof as well as the walls should contain some effective insulating material, such as sawdust, shavings, or some of the prepared insulating papers or other materials commonly used by the building trades. Large dead-air spaces between walls have been found to be relatively poor in insulating value on account of the convection currents which develop within them, permitting loss of heat from one wall to the other. Windows and doors should be shuttered.

Ample ventilators in the roof should be provided for the exit of warm and moisture-laden air, and they should be equipped with dampers that can be controlled from the floor. Cold air from the outside should be admitted when needed through screened openings near the floor. These also should be equipped with easily controlled dampers.

Large dugouts or shallow earth-covered banks or storage cellars are successfully used if adequate ventilation is provided.

In practically all instances the floor of the storage house is of earth. This is desirable if the location is well drained, since it helps maintain the high humidity of the air that is necessary to prevent serious wilting of the cabbage. As a muddy floor will cause too high humidity in the house, precautions should be taken regarding drainage.

The bins or tiers of shelves should be built on either side of a driveway that should run through the center of the house and be wide enough to accommodate a wagon and team or a motortruck. Bins should be no more than 4 feet wide, with a 6-inch space between them. All bins or shelves should be of open construction, to permit the greatest possible freedom of air circulation (fig. 18). The heads should be piled no more than 6 feet deep in the bins. Laying the heads two or three deep upon heavy shelves is satisfactory, but placing them on demountable latticelike shelves in a single layer (fig. 19) is preferable, because it affords better circulation of air and there is

less bruising and less danger of heating or decay. The construction of shelves is, of course, more expensive per ton of storage capacity than is the construction of bins. An air space of 8 to 10 inches should be left between the walls and all bins or shelves to avoid frost and afford air circulation.

As harvesttime approaches, advantage of the cool nights should be taken to cool the

storage house down to as near 33° F. as possible, keeping it shut during the day and open at night. This same procedure should be followed while the cabbage is being placed in storage. Later in the season the reverse may be necessary in order to afford needed ventilation and to prevent the house from becoming too cold. In very cold weather the house must be kept closed tight except for such slight ventilation as is necessary. Oil or coke heaters usually are needed during the coldest weather to prevent freezing in the house. They are placed at intervals in the driveway or aisles of the house.

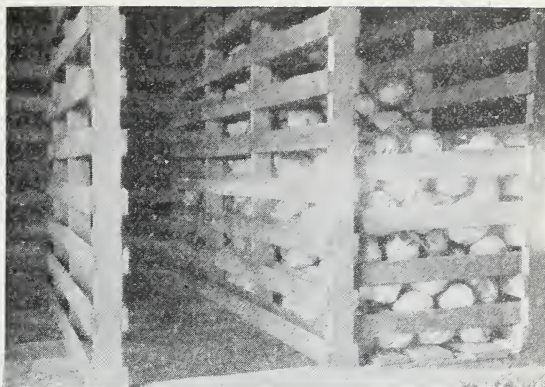


FIGURE 18.—Narrow bins with air spaces between them used for storing cabbage.

#### FARM STORAGE

On the farm small quantities of cabbage are often stored for the winter, or large quantities are stored for short periods by various methods that are sometimes fairly satisfactory but are considered less safe than the use of well-constructed houses.

For storing small quantities, the entire plant may be pulled from the soil and the outer leaves removed. The roots may then be set in moist soil in a coldframe or storage pen (fig. 20) with the heads as close together as possible. The frame or enclosure is then banked with soil and covered with sash, boards, poles, or other available material that will support a heavy thatch of straw.

The trimmed heads may be placed in a conical or a long, narrow pile, then covered with 8 or 10 inches of straw and finally a layer of soil about 8 inches to a foot thick. If the pile is to be a large one, the cabbage should be placed about an upright A-shaped frame which allows some ventilation between the heads. Another method is to build the pile over a trench which is covered by heavy, widely spaced boards, the trench serving as a means of ventilation (fig. 21). The ends of such ventilating trenches or frames should extend slightly beyond the pile of cabbage and should be well covered with straw or similar material, but the passage of air should not be entirely stopped by the soil covering. The cabbage should be well covered with both straw and soil. Sometimes, for temporary storage, the heads are spread upon straw in broad, shallow, well-drained pits and covered with straw or litter and soil.

These various pits are satisfactory only in mild regions or in instances in which the cabbage is to be removed from the pit before very cold weather. The difficulty of obtaining ventilation, the danger of

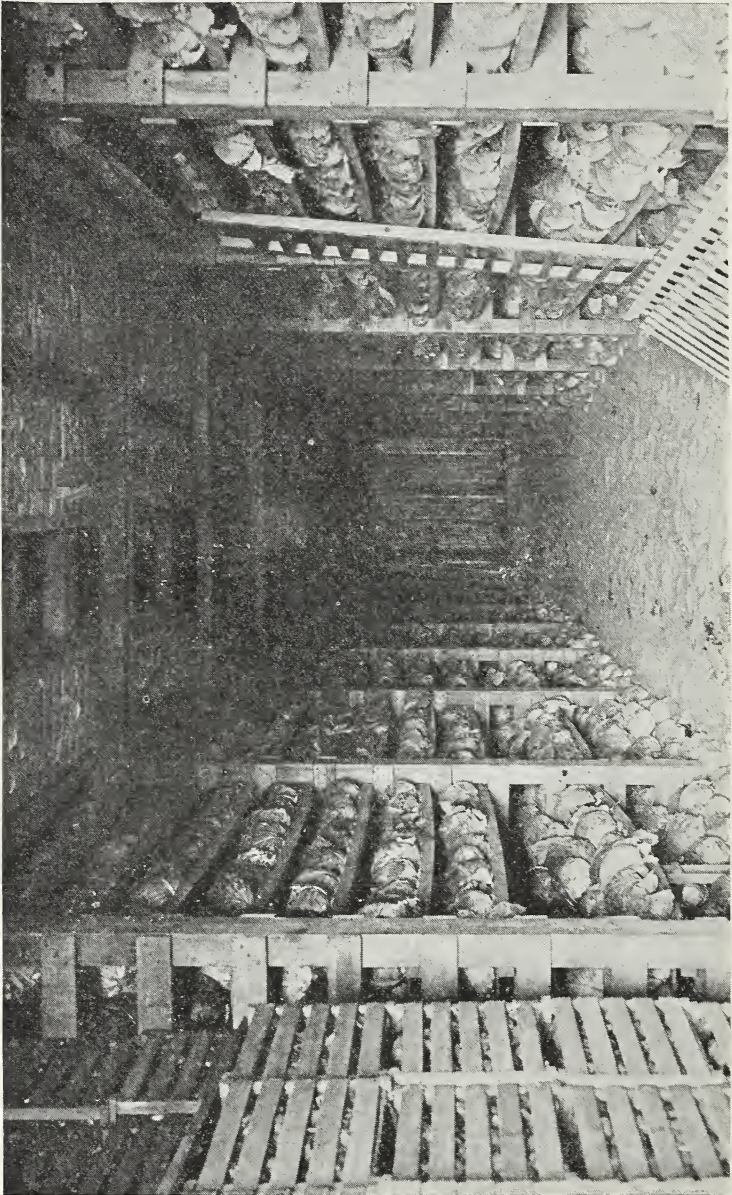


FIGURE 19.—Interior of cabbage storage house equipped with slatted removable shelves. The use of such shelves is preferable to the use of bins.

loss through decay or freezing, and the probability of bad weather interfering with the removal of the cabbage from the pits all contribute to make this general method little more than a poor substitute for proper storage.

Well-ventilated, cool cellars are satisfactory and should be managed according to the recommendations for storage houses.

#### UNITED STATES GRADES

Standard grades for stored as well as fresh market cabbage have been established. Storage conditions and the handling of the prod-

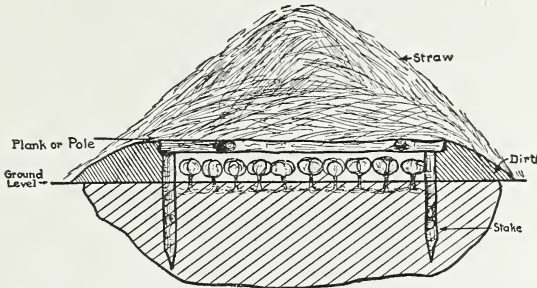


FIGURE 20.—Cross section of a cabbage storage pen made of stakes and poles and covered with straw.

uct should be so carefully managed that the highest possible proportion of the stored product can be classed as United States No. 1 upon removal from storage. The best profits can be made only upon a high-quality product, so those who store cabbage should be familiar with the specifications for the standard grades. Copies of these speci-



FIGURE 21.—A board-covered trench affording drainage and ventilation for a long pile of cabbage, which will be covered with straw and soil.

fications can be obtained by writing to the Office of Distribution, War Food Administration, Washington 25, D. C.

## DISEASE CONTROL<sup>5</sup>

Cabbage is subject to a number of diseases which may in large measure be avoided by proper attention to seed treatment, soil management, and choice of resistant varieties. Since the causal parasites of two important diseases, blackleg and black rot, are often carried with the seed, it is advisable before the seed is sown to treat it with hot water at 122° F. for 30 minutes, unless it can be ascertained that the seed was grown in the Pacific Coast States, where these germs do not affect the seed. The seedbed should be rotated from year to year to avoid the initiation of disease from germs of the previous years, some of which may live over on old cabbage debris. It is also well to select a location for the bed which is not subject to flow of surface-drainage water from higher levels where cabbage or related plants have been grown previously. Where plants are started in hotbeds or coldframes, the soil should be changed frequently or the danger of soil parasites of cabbage should be removed by steam sterilization of the soil.

Rotation of the transplanted field is also paramount to continued successful cabbage culture.

### BLACK ROT

Black rot is likely to occur wherever cabbage is grown. It also affects cauliflower, brussels sprouts, kohlrabi, kale, rape, and a number of cultivated and wild plants of the mustard family. It is caused by bacteria which may live over in the soil at least one winter in the North and are commonly carried with the seed. The black rot germs gain entrance through the water pores at the edge of the leaf and travel through the water vessels, causing them to become black in color. The infected leaves show yellowing and dying of the tissue in characteristic, often V-shaped, areas starting at the leaf margins and extending toward the midrib. As the disease progresses, leaves fall off prematurely. When the organisms have gained access to the main stem they travel upward and affect new leaves or enter the maturing head, causing the blackening of the veins sometimes throughout only a leaf or two of the head. One of the most serious phases of black rot is the fact that it opens up the way for and is usually followed by the common bacterial soft rot.

Black rot is checked by seed treatment and by rotation of seedbed and field. It should be borne in mind that other related plants harbor black rot germs, and therefore the seedbed especially should not follow cauliflower, rape, or other members of the mustard family.

### BACTERIAL SOFT ROT

Bacterial soft rot, common to most vegetables after harvest, often causes heavy losses to cabbage in storage and transit. However, the causal germs enter only through wounds caused by handling, freezing, or another parasite such as the black rot germ. This disease some-

<sup>5</sup> Prepared by J. C. Walker, agent, Division of Fruit and Vegetable Crops and Diseases. For additional information on cabbage diseases see Farmers' Bulletin 1439, Diseases of Cabbage and Related Plants (26).

times appears in the field before harvest, particularly where black rot has previously made headway.

Bacterial soft rot is so named because it consists of a softening of the tissues of head leaves and the core. This is usually accompanied by a repugnant odor.

The chief preventive measure for bacterial soft rot is care in handling the harvested crop to avoid unnecessary bruising and freezing injury. Control of black rot indirectly reduces soft rot. The crop from fields badly infected with black rot should be marketed for immediate consumption and not held in storage for any long period.

### BLACKLEG

Blackleg is so named because the causal fungus commonly attacks the plant at the base of the stem and progresses downward, causing a decay of the outer tissues and depletion of the fine roots. The advanced stages result in a sudden wilting of the plant. The fungus may attack leaves, seed stems, pods, and seed, but the heaviest loss to the cabbage grower is that resulting from stem and root injury.

The fungus is seed-borne and may also live over 1 year in the refuse of diseased plants. The precautions recommended in the case of black rot apply also in the case of blackleg.

### CLUBROOT

Clubroot is a very widespread disease of cabbage and many other members of the mustard family. It is caused by a soil organism which attacks the roots and results in swellings or clubs of various sizes and shapes. This abnormal root growth retards top growth, and plants thus become stunted while eventually the reduced supply of water results in the wilting and collapse of the plant.

Clubroot is the most difficult cabbage disease to control. The causal organism is not seed-borne, but it lives many years in the soil without the presence of a congenial host; therefore the ordinary rotation procedure is not helpful. In selecting the seedbed infested soil should be avoided. Plants should not be taken from a bed showing any disease, since even healthy-appearing plants may carry the disease germs to the field. A liberal application of hydrated lime well worked into the soil some weeks before transplanting usually reduces the disease. Use of 1-1,500 corrosive sublimate as the transplanting liquid is beneficial in reducing severity of clubroot on infested soil.

**See warning about corrosive sublimate (p. 57).**

### YELLOW

Yellow resembles black rot in that it causes a discoloration of the vessels and defoliation of the plant. However, the evidences of infection at the leaf margins are absent, since the parasite is a soil fungus which gains entrance through the root tips.

The yellow fungus, like the clubroot organism, is not seed-borne but persists indefinitely in the soil. The disease increases in severity with the rise of soil temperature and thus is most acute in midsummer. Moreover, it is of little importance on the winter crop in the South.

Fortunately, yellow has been controlled by the development of resistant varieties through the cooperative work of the United States

Department of Agriculture and the Wisconsin Agricultural Experiment Station. Several of these have been developed to meet various needs. Some of the more widely used yellows-resistant varieties are described on page 16. Seeds of these are now listed by many seedsmen.

## INSECT CONTROL<sup>9</sup>

### CATERPILLARS

The principal caterpillars that cause damage to cabbage are the cabbage looper, the diamondback moth (also known as the cabbage *plutella*), the imported cabbageworm (also known as the common cabbageworm), the cabbage webworm (or budworm), the corn earworm (also known as tomato fruitworm and cotton bollworm), and several species of cutworms. Several other species, including the cross-striped cabbageworm, sometimes occur in injurious numbers in certain areas. All these caterpillars are the immature stages of moths or butterflies.

The following recommendations are made for the control of caterpillars on cabbage during the existing wartime emergency. They provide for the minimum use of such scarce insecticides as rotenone and pyrethrum and are also designed to avoid the hazard of a harmful residue on the marketed product.

#### CONTROL DURING PLANT-PREHEADING PERIOD

To prevent damage to young plants in the plant bed or in the field and to reduce the possibilities of damage during the heading period, calcium arsenate, cryolite, or paris green should be used as a dust mixture or as a spray at least every 10 days during the preheading period of plant growth if the caterpillars are present in damaging numbers; that is, an average of more than about one caterpillar per plant. These control measures are directed principally against all cabbage caterpillars, the corn earworm, and climbing cutworms. The control methods for soil-inhabiting cutworms are discussed on page 55.

In the dust form, calcium arsenate should be applied undiluted; paris green, diluted with 9 parts, by weight, of hydrated lime; and cryolite diluted at the rate of 3 parts to 1 of talc, by weight.

In the spray form, calcium arsenate and cryolite should be used at the rate of 4 to 5 pounds and paris green at the rate of 1 pound to 50 gallons of water. Four pounds of hydrated lime should be used per 50 gallons of paris green spray.

If applications of these arsenical or fluorine compounds do not provide entirely adequate control of the corn earworm or climbing cutworms, a bait composed of 10 percent of cryolite and 90 percent of corn meal, by weight, mixed and used dry, should be sprinkled into the buds of the plants at the rate of about 25 pounds per acre just before the plants begin heading.

To avoid the hazard of a harmful residue on the marketed product, arsenicals or fluorine compounds, such as calcium arsenate, paris green, lead arsenate, or cryolite, should not be applied to cabbage after the leaves which would remain on the harvested head as prepared for market become exposed to view. In general, this means that cabbage to be marketed with four wrapper, or

<sup>9</sup> Prepared in the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.



loose, leaves should not be treated with these poisons after the head has begun to form or after the bud leaves have begun to fold or "cup over." With some varieties this folding of the central leaves usually occurs 30 to 40 days before the heads are ready for market. If it is necessary, as an emergency measure, to use fluorine compounds or arsenicals after the cabbage has begun to head, all loose leaves should be removed from the head to avoid excessive residues on the market product. Stripping of these loose leaves is not a profitable commercial practice in the case of cabbage grown for the green market.

Calcium arsenate, paris green, and cryolite are poisonous and should be handled with care and stored where children, careless persons, and domestic animals cannot reach them. In mixing or applying these insecticides especial care should be taken not to inhale excessive quantities. Well-designed respirators affording protection to the entire face should be used whenever available. Wash the hands or other exposed parts of the body thoroughly after working with these compounds.

#### CONTROL DURING PLANT-HEADING PERIOD

For the control of the green caterpillars on cabbage, under present conditions, it is recommended that rotenone-containing dust mixtures or sprays be applied at least every 10 days throughout the heading period if there is an average of more than one caterpillar per plant.

Rotenone dust mixtures should contain from 0.75 to 1.0 percent of rotenone derived from the roots of derris, cube, barbasco, tuba, or timbo. They may be prepared by mixing the finely ground root of any one of the above-named plants with such nonalkaline and finely ground diluents as talc, pyrophyllite, sulfur, or tobacco dust. For example, to prepare a dust mixture containing 1.0 percent of rotenone from ground derris root which contains 5 percent of rotenone, mix 20 pounds of the root with 80 pounds of the diluent. Rotenone sprays should contain 0.025 percent of rotenone. For example, a ground root containing 5 percent of rotenone should be used at the rate of 2 pounds to 50 gallons of water, to which should be added a nonalkaline spreader or sticker such as a mild soap, a miscible or sulfonated oil, or one of the proprietary compounds designed especially for this purpose. Sprays made from extracts of derris or of the other roots mentioned may also be used. They should be prepared according to the directions of the manufacturer.

If rotenone-containing dust mixtures or sprays are not available, pyrethrum is recommended as a substitute in the form of a dust or a spray. This insecticide is effective against the cabbage looper but is less effective than rotenone against the imported cabbageworm, the diamondback moth, and the cabbage webworm. Pyrethrum dust mixtures should contain at least 0.2 percent of total pyrethrins. These mixtures are usually available from dealers in a ready-mixed form or they may be prepared by mixing finely ground pyrethrum flowers with such nonalkaline and finely ground diluents as talc, pyrophyllite, sulfur, or tobacco dust. For example, if the pyrethrum flowers contain 1.3 percent of total pyrethrins they should be diluted at the rate of approximately 15 pounds of this material to 85 pounds of the diluent. The incorporation of 20 pounds of sulfur in 100 pounds of the mixed dust, as part of the diluting material, improves

the effectiveness and stability of pyrethrum dust mixtures. Pyrethrum sprays should contain 0.006 percent of total pyrethrins. For example, finely ground pyrethrum flowers containing 1.3 percent of total pyrethrins should be used at the rate of 2 pounds to 50 gallons of water, to which may be added one of the nonalkaline spreaders or stickers mentioned for rotenone sprays. Sprays made from extracts of pyrethrum, or with combinations of rotenone and pyrethrum extracts, may also be used at dilutions recommended by the manufacturer.

#### METHODS OF USING DUSTS AND SPRAYS

Dusts and sprays can be more effectively applied during calm periods of the day, which in many cases occur in the early morning or late afternoon. Spray applications will not be affected so much by wind as dust applications. Dusters, equipped with cloth trailers from 10 to 15 feet long, will aid materially in reducing the drift of the dust, thereby providing a better coverage of the plant. The main objective in making either spray or dust applications should be to cover all parts of the plant thoroughly with the insecticide. Experience has shown that dust mixtures applied in the early morning or late afternoon are more effective than those applied at other times. Pyrethrum dust appeared to be more effective when applied in the afternoon. The influence of these periods on the control effected can probably be attributed to the feeding habits of the insect, temperature, and moisture, as well as to wind movement.

The rate of application of dust mixtures will vary with the equipment, the size of the plants, and the type of the material; but, in general, where the applications are made with traction or power dusters, from 15 to 20 pounds of the dust mixture will be required per acre per application. Where hand dusters are used and the plants are small, permitting application of the dust to each plant individually, the rate per acre would be approximately 10 to 12 pounds. Spray mixtures should be applied at the rate of 100 to 125 gallons per acre per application when traction or power equipment is used, and at the rate of between 50 and 60 gallons per acre when hand equipment is used and the plants are in the early stages of growth.

Insecticides should be applied at regular intervals; and the first application should be made when there is an average of about one worm per plant, or when 25 percent of the plants in the field show signs of worm feeding. If the infestations continue to develop, treatments should be made every 10 days.

#### CULTURAL CONTROL MEASURES

To reduce caterpillar damage and the need for insecticides the following practices are to be recommended: When harvesting of a field has been completed the crop remains should be plowed under or otherwise disposed of. If this is not done, the old field serves as a place for the cabbage caterpillars to develop and infest other plantings. The rows should be planted a uniform width so as to permit effective adjustment and manipulation of spraying and dusting equipment. The plants in the row should be uniformly spaced to prevent crowding and a consequent poor distribution of the insecticide.

## CUTWORMS

Cutworms sometimes are very destructive to cabbage plants directly after these have been transplanted from the seedbeds to the field. These pests can be controlled readily by the use of the following poisoned bait: 1 peck or 5 pounds of dry bran, one-fourth pound of sodium fluosilicate or paris green, and 3 or 4 quarts of water; or, in large quantities, 25 pounds of dry bran, 1 pound of sodium fluosilicate or paris green, and 4 or 5 gallons of water.

To prepare the bait:

(1) Thoroughly mix the poison with the bran. This is important. Each particle of bran must carry a little poison to get a good kill. When small quantities are being made, the bait can be mixed in a bucket with a paddle, the poison being added slowly and the bran stirred at the same time. A still more effective way is to mix the poison and bran with the hands, but since soluble arsenic from the paris green is absorbed to a slight extent through the skin, there may be some objection to this method. If the hands have any cuts, scratches, or other wounds, do not put them into the bait. When making large quantities mix the poison with the bran on some flat smooth surface, using a shovel and rake in much the same way as in mixing concrete.

(2) Add the water to the mixture of bran and poison, stirring slowly all the time. Large quantities of water added at one time will wash the poison from the bran, and the result will be an uneven mixture.

Add only enough liquid to make a crumbly mass. It is a good plan to set aside a little of the mixture of dry bran and poison so that if too much water has been used this dry reserve can be added to bring the mixture up to the proper consistency. Large quantities can be made up in galvanized-iron or wooden washtubs and small quantities in buckets or similar containers.

Either broadcast the poisoned bait or sow it by hand along the rows or about the base of the plants. Do this late in the evening so that the bait will not dry out to any great extent before the worms get busy. Since many kinds of cutworms overwinter in the ground and start feeding as soon as the weather becomes favorable in the spring, it is a good plan to broadcast the poisoned bait over the field before the plants are set out.

Ten to fifteen pounds of the wet bait is enough for one application per acre. Where the bait is applied directly to the rows or hills, a smaller quantity will be sufficient. Two or three applications at 2-day intervals may be required to rid the field of the pest.

**These baits are also poisonous to other animals and man. Keep the poison and poisoned-bran bait away from farm animals and irresponsible persons.**

## CABBAGE MAGGOT

The newly hatched cabbage maggot is a tiny white creature that easily escapes observation. It develops from eggs laid by an adult fly which somewhat resembles the common housefly in appearance but is smaller and grayish. The eggs are laid just beneath the soil surface close to the young cabbage seedlings, and very soon after hatching the maggots attack the root and below-ground portions of the stem of the plants, eating away the outer layers just below the soil surface. Later, as the maggots become larger, they feed on the part of the stem deeper in the soil, and many burrow into the stem; but for the most part they feed on the roots, damaging them severely or entirely destroying them.

Maggot injury in the seedbed is usually first evidenced by certain plants becoming lighter and more bluish than others in the bed. In hot or dry weather these injured plants wilt readily, and many may die.

Upon further examination it will be found that these plants can be drawn from the soil very easily because many of the roots have been destroyed. In some cases the roots will be almost all destroyed. In a large seedbed the injury usually appears in spots or patches. Most of the affected plants do not die but are severely stunted in the plant bed and may die after transplanting; at least they make such poor growth as to be practically a total loss.

Screening the seedbed is one of the best maggot-control measures. Before the seedlings are up, a coarse cheesecloth having 20 to 30 threads per inch is stretched tightly over the beds, preferably tacked to board frames at the edges of the beds, much like coldframes. The cloth should be sewn together to make a single, insectproof cover for each bed. If the beds are more than 6 feet wide, wires should be stretched tightly across or along the beds, attached to the top of the frames, to keep the cloth from sagging down on the plants. The frames should be banked slightly with soil, and the covers should fit tightly to prevent the entrance of any flies. The cover may be removed for the brief periods necessary for watering, cultivating, or weeding, but it should be replaced as quickly as possible.

On account of the shading effect of the cloth, special precautions must be taken to avoid crowding the plants or promoting too succulent growth by means of rich soil or fertilizer. The cover should be removed a week or 10 days before the plants are to be set out, to harden them.

Some growers insist that plants grown without covers are sturdier and stand transplanting so much better than those grown under screens that they prefer other methods for control of the maggot.

Corrosive sublimate solution is applied to the soil about the base of the plant at the rate of 1 gallon for each 20 to 40 feet of row, depending on the age of the seedlings, the lesser amount being applied to the younger plants. The solution is prepared by dissolving 1 ounce of corrosive sublimate in about a half gallon of hot water, then adding this concentrated solution to 10 to 12 gallons of cold water, and stirring thoroughly. This solution may be applied by any device that will deliver a small stream at the base of the plants in the rows in the seedbed. For very young seedlings, a solution of 1 ounce of corrosive sublimate to 15 gallons of water is safer. Corrosive sublimate is only slightly soluble in cold water. Care must be taken, as directed, to insure that it is all dissolved; else the solution may be too weak to be effective. Solutions should be prepared in earthenware, glass, or wooden containers, because they corrode metals. Galvanized cans or other metal equipment used to apply the solutions must be thoroughly rinsed immediately after being used, and the solutions must not be allowed to stand in them.

The time for the first application has no relation to the size of the plants but depends entirely on the appearance of the insect. In the Northern States where the cabbage maggot is injurious, the adult usually begins laying eggs about the time that European varieties of plums are in bloom. The actual date varies, of course, from year to year in one location and from place to place in the same year. Careful inspection of the soil at the base of the plants should reveal the presence of eggs soon after the flies have begun to deposit them. Applications should begin with the first evidence of eggs and continue at intervals of a week to 10 days, unless the infestation is known

to be light, when one or two well-timed treatments may give satisfactory control. Some experience is necessary to obtain the most efficient results.

**Corrosive sublimate is very poisonous and must be handled with proper care. It should be stored in containers plainly labeled "Poison." It is advisable to wear rubber gloves when working with this compound.**

Calomel may be used instead of corrosive sublimate for the control of this pest. Its use is especially recommended for seedbeds of cauliflower and brussels sprouts. Apply a liquid mixture composed of 1 ounce of calomel in 10 gallons of water to the base of the plants in the seedbed soon after they appear above ground, and repeat at 7- to 10-day intervals until four treatments have been applied. For plants in the field pour one-half teaspoonful of the mixture around the base of each plant soon after setting it and repeat 7 to 10 days later. For plants in rows, apply the mixture at the rate of 1 gallon per 35 feet of row. To prepare this mixture, make the required amount of calomel into a paste and then add it to the water. Keep the mixture well stirred at frequent intervals to prevent the settling of the calomel. Calomel can be applied as a dust mixed with gypsum (land plaster) or any similar inert carrier, at the rate of 1 pound of calomel to 24 pounds of the carrier. Apply around the base of the plant in the field or in the seedbed in the same manner as when using the liquid mixture. At the time of transplanting seedlings, they may be protected by dipping the entire root and stem in a heavy liquid mixture of 8 ounces of calomel per 10 gallons of water or by applying the undiluted calomel powder to the moistened stem of the seedlings before setting them out.

**Calomel is not generally regarded as dangerously poisonous, being commonly used in small doses as a purgative. Nevertheless, it should be stored in labeled containers out of the reach of children and irresponsible persons, since excessive doses are poisonous.**

#### HARLEQUIN BUG

The harlequin bug causes damage of commercial importance normally only in the Cotton Belt. It is a brilliantly colored red and black bug that sucks the sap from the leaves of cabbage and related crops. The eggs are easily identified by their resemblance to white barrels with black hoops and a black spot in the position of the bunghole.

The harlequin bug can be best controlled by the preventive measures indicated below. These consist of clean cultural methods, planting trap crops, and hand-picking the insects.

All remains of cabbage or related crops should be completely plowed under promptly after the crop is harvested. Wild plants of the mustard family should be kept down as completely as possible. In fact, any rank weed growth or rubbish may harbor the insects over winter.

The favorite food plants of the insect are horseradish, mustard, rape, and kale. Early plantings of these crops may be made about the borders and at intervals through the cabbage field to attract the bugs that first appear. The bugs can then be killed by spraying them with kerosene or otherwise destroying the plants upon which they are collected. The few bugs that escape the trap crops may be hand-

picked from the cabbage. A combination of trap cropping and hand-picking has been proved thoroughly practicable and effective.

The conspicuous appearance and sluggish nature of the harlequin bug make it easy to capture. Hand-picking by knocking the bugs from the plant into a shallow pan containing a small quantity of kerosene is useful. Close watch should be kept for the bugs that first appear. If these few are exterminated, the damage will be greatly reduced for the season and but few bugs will appear later.

Since the harlequin bug is a sucking instead of a chewing insect, stomach poisons have no effect upon it. To kill the insects a contact insecticide must be used and the bugs must be thoroughly covered with the material. This is an extremely difficult task, because the plants upon which the insects feed usually attain such a dense growth that it is practically impossible to reach the insects on all parts of the plant. In some sections of the South where turnips and mustard are sown broadcast for greens an insecticide application is impracticable.

A large number of insecticides have been tested over a period of years to determine their effectiveness against the harlequin bug. Results of these tests led to the recommendation of derris extract spray and derris dust for control of this insect. Results of more recent work by Walker and Anderson (25) show that a spray prepared by adding a wetting or spreading agent and 4 pounds of derris or cube root powder containing 5 or 6 percent of rotenone to 50 gallons of water is effective for control of the harlequin bug. Growers who prefer to dust or are not equipped to spray should use a rotenone or pyrethrum dust as recommended for caterpillars.

It should be borne in mind that only those insects actually hit by the insecticide are killed. Thoroughness of application is therefore of prime importance.

#### APHIDS, OR PLANT LICE

The turnip aphid and the cabbage aphid are similar tiny, soft-bodied, sucking insects that can be controlled by contact poisons such as nicotine sulfate but cannot be controlled by stomach poisons. As in controlling all insects, it is especially important to start treatments as soon as the first infestation is evident. Controlling the first light attack is usually not very difficult; but if control measures are neglected until the field is heavily infested, the damage is certain to be serious and control measures will be of doubtful success. The infested leaves soon crumple and curl downward around the insects so that it is difficult to reach them with dust or spray.

The first few scattered infestations in a field can often be cleaned up by applying a 3-percent nicotine dust to the infested plants with a hand-operated duster. If the field is of more than 2 or 3 acres and the infestation is general, horse-drawn or power dusters or sprayers can be used more efficiently.

The field may be sprayed with a nicotine sulfate-soap solution, made as follows: Three-fourths pint of nicotine sulfate (40 percent nicotine), 2 pounds of soap, and 50 gallons of water. About 100 gallons of spray solution is required per acre for a uniform application. Thirty to forty pounds of dust per acre are needed. If the plants are small or if only small infested areas are to be treated, obviously less material will be required.

A derris or cube dust mixture containing 0.5 percent of rotenone, made by diluting the ground root with equal parts of finely ground tobacco dust and sulfur, is recommended for the control of the turnip aphid. Good results in controlling this insect have been obtained also with a rotenone spray consisting of 2 pounds of finely ground derris or cube root (containing from 4 to 5 percent of rotenone) to 50 gallons of water. Dusts or sprays containing rotenone are not so effective as nicotine in combating the cabbage aphid.

#### PREPARATION OF SPRAY AND DUST MIXTURES

In preparing spray mixtures for controlling insects the following method should be used: Half fill the spray tank with water, running it through a fine strainer. Put the required amount of the powder to be used in a bucket, add a little water, and work up a paste of the material, thoroughly wetting every particle of the powder. Add enough water so that the mixture can be stirred easily and then pour this through the strainer into the spray tank and add the remainder of the water required. If soap is added as a spreader, it should be dissolved in a small quantity of hot water, then added to the spray mixture. Thoroughly stir the whole mixture.

An easy way to prepare dust mixtures is to place the ingredients in a drum, barrel, or large can, together with a few stones about the size of a baseball, and close the container tightly. Then roll it a total distance of about 500 feet, turning it end over end a few times about every 50 feet. The container should be no more than one-half or two-thirds full of material, allowing plenty of space for the material to move about freely as the container is turned or rolled.

#### LITERATURE CITED

- (1) ARTHUR, J. M.  
1929. SOME EFFECTS OF RADIANT ENERGY ON PLANTS. *Optical Soc. Amer. Jour. and Rev. Sci. Instruments* 18: 253-263, illus.
- (2) ———  
1930. SOME EFFECTS OF ARTIFICIAL CLIMATES ON THE GROWTH AND CHEMICAL COMPOSITION OF PLANTS. *Amer. Jour. Bot.* 17: 416-482, illus.
- (3) BEATTIE, J. H.  
1923. GREENHOUSE CONSTRUCTION AND HEATING. U. S. Dept. Agr. *Farmers' Bul.* 1318, 38 pp., illus.
- (4) ——— and BEATTIE, W. R.  
1931. THE FARM GARDEN. U. S. Dept. Agr. *Farmers' Bul.* 1673, 68 pp., illus.
- (5) BLAIR, A. W., and PRINCE, A. L.  
1930. THE INFLUENCE OF LIME IN VEGETABLE GROWING. *N. J. Agr. Expt. Sta. Bul.* 498, 16 pp., illus.
- (6) BOSWELL, V. R.  
1929. STUDIES OF PREMATURE FLOWER FORMATION IN WINTERED-OVER CABBAGE. *Md. Agr. Expt. Sta. Bul.* 313, pp. 69-145, illus.
- (7) ——— and JACKSON, A. M.  
1931. EXPERIMENTS WITH ULTRA-VIOLET TRANSMITTING GLASSES FOR GROWING VEGETABLE PLANTS IN COLDFRAMES. *Amer. Soc. Hort. Sci. Proc.* 28: 375-379.
- (8) CHATFIELD, C., and ADAMS, G.  
1931. PROXIMATE COMPOSITION OF FRESH VEGETABLES. U. S. Dept. Agr. *Cir.* 146, 24 pp.
- (9) COMIN, D., and BUSHNELL, J.  
1928. FERTILIZERS FOR EARLY CABBAGE, TOMATOES, CUCUMBERS, AND SWEET CORN. *Ohio Agr. Expt. Sta. Bul.* 420, 42 pp., illus.
- (10) ——— and SHERMAN, W.  
1930. SUBSTITUTES FOR GLASS ON HOTBEDS AND COLDFRAMES. *Ohio Agr. Expt. Sta. Bimo. Bul.* 144: 70-78, illus.

- (11) EDMOND, J. B., and LEWIS, E. P.  
1926. INFLUENCE OF NUTRIENT SUPPLY ON EARLINESS OF MATURITY IN CABBAGE. Mich. Agr. Expt. Sta. Tech. Bul. 75, 16 pp.
- (12) ELTINGE, E. T.  
1928. THE EFFECT OF ULTRA-VIOLET RADIATION UPON HIGHER PLANTS. Missouri Bot. Gard. Ann. 15: 169-240, illus.
- (13) GOURLEY, J. H., and MAGRUDER, R.  
1924. MANURES AND FERTILIZERS FOR TRUCK CROPS. Ohio Agr. Expt. Sta. Bul. 377, pp. 117-152, illus.
- (14) HARTER, L. L.  
1909. THE CONTROL OF MALNUTRITION DISEASES OF TRUCK CROPS. Va. Truck Expt. Sta. Bul. 1, 16 pp., illus.
- (15) HARTWELL, B. L., and DAMON, S. C.  
1920. FERTILIZER VERSUS MANURE FOR CONTINUOUS VEGETABLE GROWING. R. I. Agr. Expt. Sta. Bul. 182, 11 pp.
- (16) HAUCK, C. W.  
1924. PREPARATION OF CABBAGE FOR MARKET. U. S. Dept. Agr. Farmers' Bul. 1423, 14 pp., illus.
- (17) LOOMIS, W. E.  
1925. STUDIES IN THE TRANSPLANTING OF VEGETABLE PLANTS. N. Y. (Cornell) Agr. Expt. Sta. Mem. 87, 63 pp., illus.
- (18) MACK, W. B.  
1927. FERTILIZATION OF TRUCK CROPS IN ROTATION. Pa. Agr. Expt. Sta. Bul. 210, 31 pp.
- (19) MILLER, J. C.  
1929. A STUDY OF SOME FACTORS AFFECTING SEED-STALK DEVELOPMENT IN CABBAGE. N. Y. (Cornell) Agr. Expt. Sta. Bul. 488, 46 pp., illus.
- (20) MYERS, C. E.  
1916. EXPERIMENTS WITH CABBAGE. Pa. Agr. Expt. Sta. Bul. 137, 15 pp., illus.
- (21) SMITH, S. L.  
1929. VITAMINS IN FOOD MATERIALS. U. S. Dept. Agr. Cir. 84, 55 pp., illus.
- (22) SPANGLER, R. L.  
1938. MARKETING COMMERCIAL CABBAGE. U. S. Dept. Agr. Tech. Bul. 646, 126 pp., illus.
- (23) THOMPSON, H. C.  
1927. EXPERIMENTAL STUDIES OF CULTIVATION OF CERTAIN VEGETABLE CROPS. N. Y. (Cornell) Agr. Expt. Sta. Mem. 107, 73 pp., illus.
- (24) ——— WESSELS, P. H., and MILLS, H. S.  
1931. CULTIVATION EXPERIMENTS WITH CERTAIN VEGETABLE CROPS ON LONG ISLAND. N. Y. (Cornell) Agr. Expt. Sta. Bul. 521, 14 pp.
- (25) WALKER, H. G., and ANDERSON, L. D.  
1939. FURTHER NOTES ON THE CONTROL OF THE HARLEQUIN BUG. Jour. Econ. Ent. 32: 225-228.
- (26) WALKER, J. C.  
1927. DISEASES OF CABBAGE AND RELATED PLANTS. U. S. Dept. Agr. Farmers' Bul. 1439, 30 pp., illus.
- (27) WARE, L. M.  
1930. FERTILIZER WORK WITH CABBAGE. Miss. Agr. Expt. Sta. Cir. 91, [4] pp.
- (28) WEAVER, J. E., and BRUNER, W. E.  
1927. ROOT DEVELOPMENT OF VEGETABLE CROPS. 351 pp., illus. New York.
- (29) WHITE, T. H., and BOSWELL, V. R.  
1929. AMOUNTS OF FERTILIZER AND MANURE REQUIRED FOR MAINTENANCE OF FERTILITY FOR VEGETABLE PRODUCTION. Md. Agr. Expt. Sta. Bul. 309, pp. 429-444.
- (30) ZIMMERLEY, H. H.  
1922. CABBAGE STRAIN TESTS. Va. Truck Expt. Sta. Bul. 37/38, pp. [211]-220.
- (31) ——— and PARKER, M. M.  
1925. CABBAGE FERTILIZERS. Va. Truck Expt. Sta. Bul. 50, pp. [367]-378.





